E-20-G85
#1

Georgia Institute of Technology
School of Civil and Environmental Engineering

Structural Engineering, Mechanics and Materials
Research Report No. 03-1

Flexural Response of SEATIMBER® and SEAPILE® Components Reinforced with E-Glass Bars

Final Report

Prepared for

Seaward International

by

A. Zureick, Y.S. Kim

July 2002

Georgia Institute of Technology

School of Civil and Environmental Engineering

Structural Engineering, Mechanics and Materials
Research Report No. 03-1

Flexural Response of SEATIMBER® and SEAPILE® Components Reinforced with E-Glass Bars

Final Report

Prepared for

Seaward International

by

A. Zureick, Y.S. Kim

July 2002

Flexural Response of SEATIMBER® and SEAPILE® Components Reinforced with E-Glass Bars

Submitted by

Dr. Abdul-Hamid Zureick and
Dr. Yeonsoo S. Kim

Georgia Institute of Technology

June 2002

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Flexural Response of SEATIMBER® and SEAPILE® Components Reinforced with E-Glass Bars

INTRODUCTION

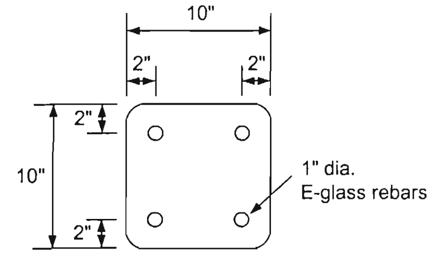
This report presents the results of an experimental investigation aimed at determining the flexural properties of 49 SEATIMBER® and SEAPILE® composite marine timber components manufactured by Seaward International, Inc., Clearbrook, Virginia. Test components had rectangular, square, and circular cross sections and were made of recycled plastic materials with and without internal E-glass reinforceement bars. In addition, test results on three wood components and one recycled plastic component not manufactured by Seaward International are also presented.

TEST COMPONENTS

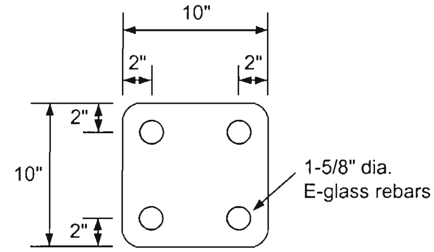
Test components had three different cross sections: rectangular, square, and circular. The designation, nominal dimensions and reinforcing scheme for each component are shown in Figure 1 and listed in Tables 1, 2, and 3. In these tables, test components are designated by a combination of letters and numbers in the form *MA-a* x *b-pFmn-L*. The *MA* represents a specific type of material, *a* x *b* are the nominal width and depth of the section, *p* is the number of reinforcing bars, *Fmn* represent the size of the bar (e.g. F08 indicates number 8 bar having a nominal diameter of 8/8 inches), and L is the test span.

TEST PROCEDURE

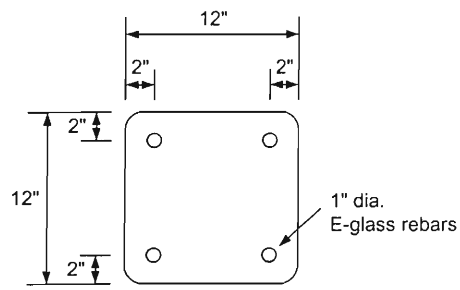
A screw-type testing machine equipped with a load cell was used for all tests. A typical test set-up is shown schematically in Figure 2 with a photograph in Figure 3. Test components rested on end bearing plates with a knife-edge type support (Figure 4) at one end and a steel rod free to roll (Figure 5) as the component was loaded at the other end. The bearing plates were provided to avoid premature end failures during the duration of the test. One linear variable differential transformer (LVDT) was placed at midspan to measure the deflection. The load was applied at midspan by means of 6-inch diameter cylinders connected to the load cell of the testing machine at the rate of 0.2 in./minute until the ultimate load was reached. Load and deflection data were collected using an Optim Megadac data aquisition system.



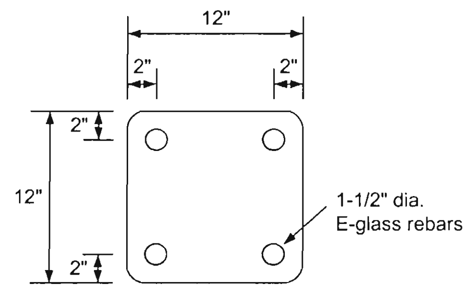
10x10 specimen with 1" E-glass rebars
(SW-10x10-4F08-xx)



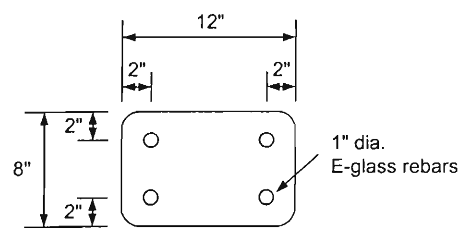
10x10 specimen with 1-5/8" E-glass rebars
(SW-10x10-4F13-xx)



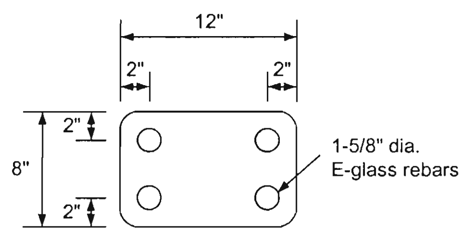
12x12 specimen with 1" E-glass rebars
(SW-12x12-4F08-xx)



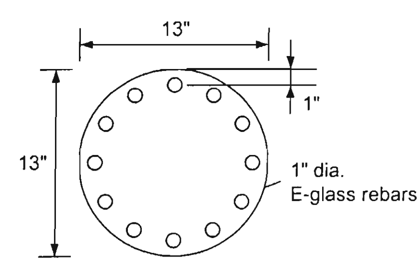
12x12 specimen with 1-1/2" E-glass rebars
(SW-12x12-4F12-xx)



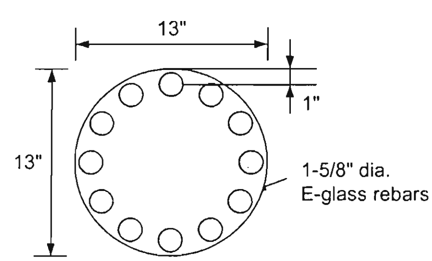
12x8 specimen with 1" E-glass rebars
(SW-12x8-4F08-xx, SW-8x12-4F08-xx)



12x8 specimen with 1-5/8" E-glass rebars
(SW-12x8-4F13-xx, SW-8x12-4F13-xx)



13" dia. specimen with 1" E-glass rebars
(SW-D13-12F08-xx)



13" dia. specimen with 1-5/8" E-glass rebars
(SW-D13-12F13-xx)

Figure 1. Nominal dimensions of test components

Table 1. Nominal dimensions of "as received" SEATIMBER® components

Specimen	Width in (mm)	Height in (mm)	Length ft (mm)	Span Length ft (mm)	E-Glass Bar Diameter in (mm)
SW-10x10-0F0-5.5	10 (254)	10 (254)	7.5 (2,286)	5.5 (1,676)	N/A
SW-10x10-0F0-6.5	10 (254)	10 (254)	8.5 (2,951)	6.5 (1,981)	N/A
SW-10x10-0F0-8.5	10 (254)	10 (254)	10.5 (3,200)	8.5 (2,951)	N/A
SW-10x10-0F0-14	10 (254)	10 (254)	17 (5,182)	14 (4,267)	N/A
SW-10x10-4F08-5.5	10 (254)	10 (254)	7.5 (2,286)	5.5 (1,676)	1.0 (25.4)
SW-10x10-4F08-6.5	10 (254)	10 (254)	8.5 (2,951)	6.5 (1,981)	1.0 (25.4)
SW-10x10-4F08-8.5	10 (254)	10 (254)	10.5 (3,200)	8.5 (2,951)	1.0 (25.4)
SW-10x10-4F08-14	10 (254)	10 (254)	17 (5,182)	14 (4,267)	1.0 (25.4)
SW-10x10-4F13-5.5	10 (254)	10 (254)	7.5 (2,286)	5.5 (1,676)	1.625 (41.3)
SW-10x10-4F13-6.5	10 (254)	10 (254)	8.5 (2,951)	6.5 (1,981)	1.625 (41.3)
SW-10x10-4F13-8.5	10 (254)	10 (254)	10.5 (3,200)	8.5 (2,951)	1.625 (41.3)
SW-10x10-4F13-14	10 (254)	10 (254)	17 (5,182)	14 (4,267)	1.625 (41.3)
SW-12x12-4F08-5.5	12 (305)	12 (305)	7.5 (2,286)	5.5 (1,676)	1.0 (25.4)
SW-12x12-4F08-6.5	12 (305)	12 (305)	8.5 (2,951)	6.5 (1,981)	1.0 (25.4)
SW-12x12-4F08-8.5	12 (305)	12 (305)	10.5 (3,200)	8.5 (2,951)	1.0 (25.4)
SW-12x12-4F08-14	12 (305)	12 (305)	17 (5,182)	14 (4,267)	1.0 (25.4)
SW-12x12-4F12-5.5	12 (305)	12 (305)	7.5 (2,286)	5.5 (1,676)	1.5 (38.1)
SW-12x12-4F12-6.5	12 (305)	12 (305)	8.5 (2,951)	6.5 (1,981)	1.5 (38.1)
SW-12x12-4F12-8.5	12 (305)	12 (305)	10.5 (3,200)	8.5 (2,951)	1.5 (38.1)
SW-12x12-4F12-14	12 (305)	12 (305)	17 (5,182)	14 (4,267)	1.5 (38.1)
SW-12x8-4F08-3.5	12 (305)	8 (203)	5.0 (1,524)	3.5 (1,067)	1.0 (25.4)
SW-12x8-4F08-4.5	12 (305)	8 (203)	6.0 (1,829)	4.5 (1,372)	1.0 (25.4)
SW-12x8-4F08-5.5	12 (305)	8 (203)	7.5 (2,286)	5.5 (1,676)	1.0 (25.4)
SW-12x8-4F08-9.5	12 (305)	8 (203)	11.5 (3,505)	9.5 (2,896)	1.0 (25.4)
SW-8x12-4F08-5.5	8 (203)	12 (305)	7.5 (2,286)	5.5 (1,676)	1.0 (25.4)
SW-8x12-4F08-6.5	8 (203)	12 (305)	8.5 (2,951)	6.5 (1,981)	1.0 (25.4)
SW-8x12-4F08-8.5	8 (203)	12 (305)	10.5 (3,200)	8.5 (2,951)	1.0 (25.4)
SW-8x12-4F08-14	8 (203)	12 (305)	17 (5,182)	14 (4,267)	1.0 (25.4)
SW-12x8-4F13-3.5	12 (305)	8 (203)	5.0 (1,524)	3.5 (1,067)	1.625 (41.3)
SW-12x8-4F13-4.5	12 (305)	8 (203)	6.0 (1,829)	4.5 (1,372)	1.625 (41.3)
SW-12x8-4F13-5.5	12 (305)	8 (203)	7.5 (2,286)	5.5 (1,676)	1.625 (41.3)
SW-12x8-4F13-9.5	12 (305)	8 (203)	11.5 (3,505)	9.5 (2,896)	1.625 (41.3)
SW-8x12-4F13-5.5	8 (203)	12 (305)	7.5 (2,286)	5.5 (1,676)	1.625 (41.3)
SW-8x12-4F13-6.5	8 (203)	12 (305)	8.5 (2,951)	6.5 (1,981)	1.625 (41.3)
SW-8x12-4F13-8.5	8 (203)	12 (305)	10.5 (3,200)	8.5 (2,951)	1.625 (41.3)
SW-8x12-4F13-14	8 (203)	12 (305)	17 (5,182)	14 (4,267)	1.625 (41.3)

Table 2. Nominal dimensions of "as received" SEAPILE® components

Specimen	Diameter, in (mm)	Length ft (mm)	Span Length ft (mm)	E-Glass Bar Diameter, in (mm)
SW-D13-12F08-6	13 (330)	8.0 (2,438)	6 (1,829)	1.0 (25.4)
SW-D13-12F08-7	13 (330)	9.0 (2,743)	7 (2,134)	1.0 (25.4)
SW-D13-12F08-9.5	13 (330)	11.5 (3,505)	9.5 (2,896)	1.0 (25.4)
SW-D13-12F08-15	13 (330)	18.0 (5,486)	15 (4,572)	1.0 (25.4)
SW-D13-12F08-21.5	13 (330)	25.5 (7,772)	21.5 (6,553)	1.0 (25.4)
SW-D13-12F13-6	13 (330)	8.0 (2,438)	6 (1,829)	1.625 (41.3)
SW-D13-12F13-21.5	13 (330)	25.5 (7,772)	21.5 (6,553)	1.625 (41.3)

Table 3. Nominal dimensions of "as received" Southern Yellow Pine (S.Y. Pine) and Type-P components

Specimen	Width, in (mm)	Height, in (mm)	Length ft (mm)	Span Length ft (mm)	E-Glass Bar Diameter, in (mm)
SY-10x10-5.5	10 (254)	10 (254)	7.5 (2,286)	5.5 (1,676)	N/A
SY-10x10-6.5	10 (254)	10 (254)	10.5 (3,200)	8.5 (2,951)	N/A
SY-10x10-14	10 (254)	10 (254)	17 (5,182)	14 (4,267)	N/A
P-9x9-6.5	9 (229)	9 (229)	8.5 (2,951)	6.5 (1,981)	N/A

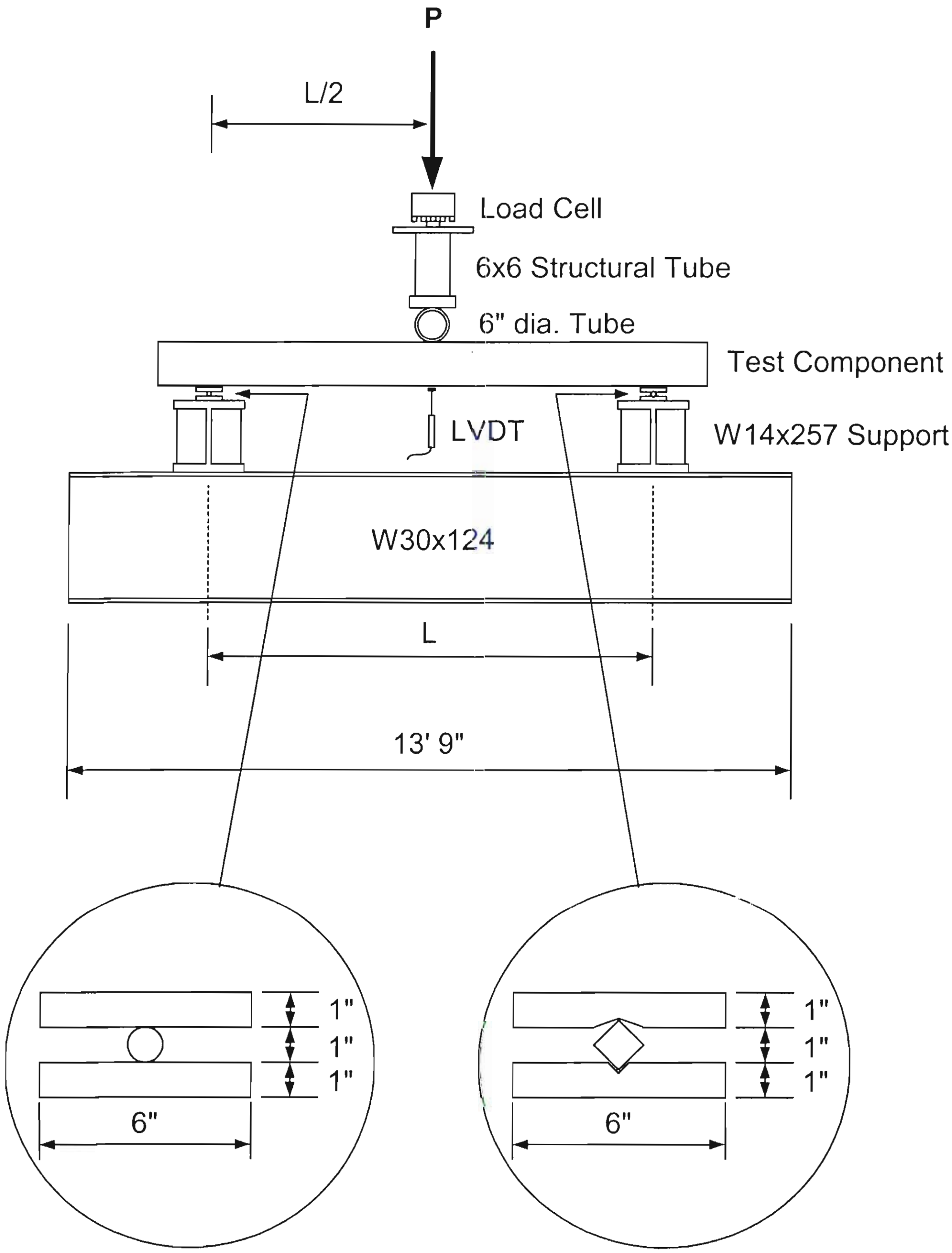


Figure 2. Typical test setup

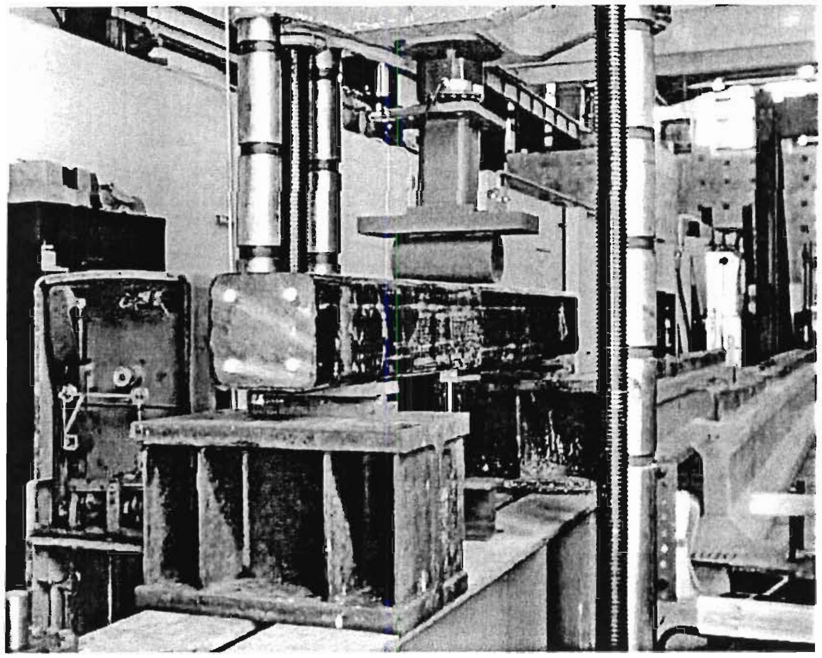


Figure 3. Photograph of a typical test set-up

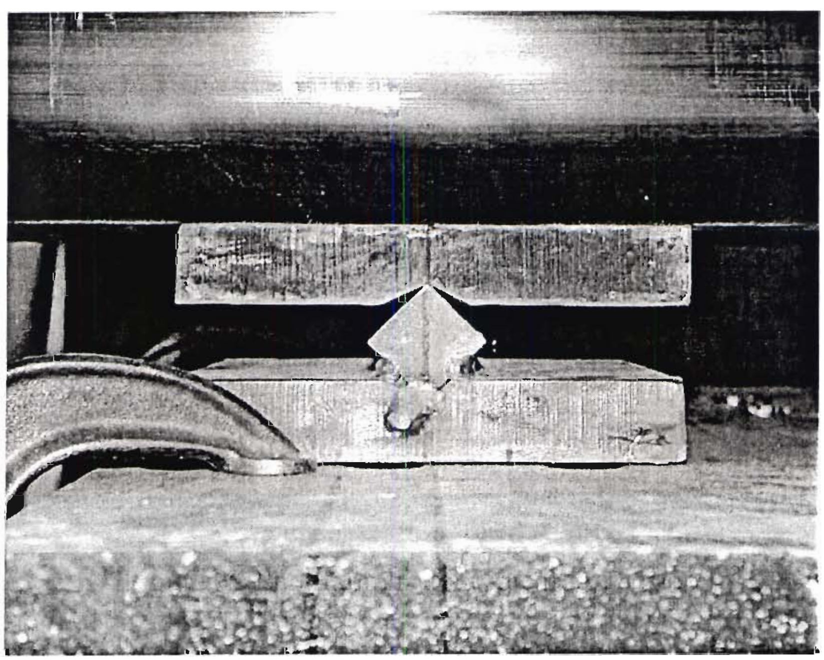


Figure 4. Knife-edge support

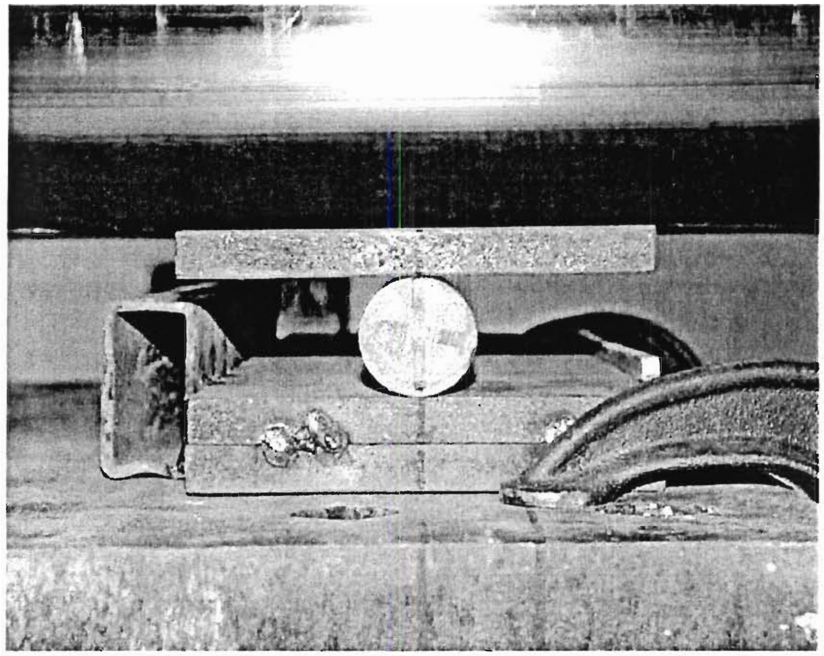


Figure 5. Roller support

TEST RESULTS

Table 4, 5, and 6 presents the ultimate load, the maximum deflection, and the mode of failure of each test components. The load-deflection curves for all test components are presented in Figure A-1 through Figure A-12 in Appendix.

Table 4. Test results for SEATIMBER® components

Test Number	Test Component	Maximum Load, kips (kN)	Deflection at Maximum Load, in (mm)	Failure Mode
1	SW-10x10-0F0-5.5	39.9 (178)	4.7 (119)	Plastic rupture-external crack
2	SW-10x10-0F0-6.5	23.1 (103)	3.4 (86)	Plastic rupture-External crack
3	SW-10x10-0F0-8.5	22.1 (98)	9.5 (242)	Test was terminated
4	SW-10x10-0F0-14	10.1 (45)	16.1 (409)	Test was terminated
5	SW-10x10-4F08-5.5	55.2 (246)	2.0 (50)	Plastic/Glass bar debonding
6	SW-10x10-4F08-6.5	55.5 (247)	3.0 (77)	Plastic/Glass bar debonding
7	SW-10x10-4F08-8.5	51.0 (227)	5.2 (131)	Plastic/Glass bar debonding
8	SW-10x10-4F08-14	32.1 (143)	12.1 (308)	Cracking sound-Internal crack
9	SW-10x10-4F13-5.5	56.8 (253)	2.5 (63)	Plastic/Glass bar debonding
10	SW-10x10-4F13-6.5	47.6 (212)	1.7 (43)	Plastic/Glass bar debonding
11	SW-10x10-4F13-8.5	48.7 (217)	2.6 (66)	Plastic/Glass bar debonding
12	SW-10x10-4F13-14	42.4 (189)	10.5 (267)	Cracking sound-Internal crack
13	SW-12x12-4F08-5.5	83.8 (373)	1.6 (40)	Plastic/Glass bar debonding
14	SW-12x12-4F08-6.5	60.3 (268)	2.0 (51)	Plastic/Glass bar debonding
15	SW-12x12-4F08-8.5	69.7 (310)	5.6 (142)	Plastic/Glass bar debonding
16	SW-12x12-4F08-14	45.0 (200)	10.5 (266)	Cracking sound-Internal crack
17	SW-12x12-4F12-5.5	132.9 (591)	2.2 (54)	Plastic/Glass bar debonding
18	SW-12x12-4F12-6.5	75.3 (335)	1.5 (37)	Plastic/Glass bar debonding
19	SW-12x12-4F12-8.5	89.2 (397)	3.2 (82)	Plastic/Glass bar debonding
20	SW-12x12-4F12-14	71.5 (318)	8.5 (217)	Cracking sound-Internal crack
21	SW-12x8-4F08-3.5	48.1 (214)	3.8 (96)	Plastic Rupture
22	SW-12x8-4F08-4.5	38.7 (172)	1.9 (47)	Plastic/Glass bar debonding
23	SW-12x8-4F08-5.5	26.1 (116)	3.5 (90)	Plastic/Glass bar debonding
24	SW-12x8-4F08-9.5	21.4 (95)	8.0 (204)	Cracking sound-Internal crack
25	SW-8x12-4F08-5.5	52.5 (234)	1.9 (47)	Cracking sound-Internal crack
26	SW-8x12-4F08-6.5	40.2 (179)	2.3 (59)	Plastic/Glass bar debonding
27	SW-8x12-4F08-8.5	30.8 (137)	7.8 (198)	Cracking sound-Internal crack
28	SW-8x12-4F08-14	18.1 (80)	9.3 (235)	Cracking sound-Internal crack
29	SW-12x8-4F13-3.5	47.9 (213)	3.0 (77)	Plastic/Glass bar debonding
30	SW-12x8-4F13-4.5	31.4 (140)	2.0 (50)	Plastic/Glass bar debonding
31	SW-12x8-4F13-5.5	32.3 (144)	1.9 (48)	Plastic/Glass bar debonding
32	SW-12x8-4F13-9.5	23.0 (102)	4.5 (114)	Plastic/Glass bar debonding
33	SW-8x12-4F13-5.5	36.3 (161)	1.7 (43)	Plastic/Glass bar debonding
34	SW-8x12-4F13-6.5	35.7 (159)	2.4 (62)	Plastic/Glass bar debonding
35	SW-8x12-4F13-8.5	34.7 (154)	3.1 (79)	Plastic/Glass bar debonding
36	SW-8x12-4F13-14	23.4 (104)	5.8 (147)	Plastic/Glass bar debonding

Table 5. Test results for SEAPILE® components

Test Number	Test Component	Maximum Load, kips (kN)	Deflection at Maximim Load, in (mm)	Failure Mode
37	SW-D13-12F08-6	66.5 (296)	3.7 (94)	Plastic/Glass bar debonding
38	SW-D13-12F08-7	60.6 (270)	4.4 (112)	Plastic/Glass bar debonding
39	SW-D13-12F08-9.5	48.9 (218)	5.0 (126)	Cracking sound-Internal crack
40	SW-D13-12F08-15	27.4 (122)	7.3 (186)	Cracking sound-Internal crack
41	SW-D13-12F08-21.5	25.7 (114)	17.2 (438)	Cracking sound-Internal crack
42	SW-D13-12F13-6	88.3 (393)	3.1 (79)	Plastic rupture-External crack
43	SW-D13-12F13-21.5	50.5 (225)	12.0 (305)	Cracking sound-Internal crack

Table 6. Test results for S.Y. Pine and Type-P components

Test Number	Test Component	Maximum Load, kips (kN)	Deflection at Maximim Load, in (mm)	Failure Mode
44	SY-10x10-5.5	34.0 (152)	0.4 (9)	Wood Rupture
45	SY-10x10-8.5	26.9 (120)	1.0 (26)	Wood Rupture
46	SY-10x10-14	13.5 (60)	1.8 (45)	Wood Rupture
47	P-9x9-6.5	9.9 (44)	3.3 (84)	Plastic Rupture-External crack

Table 7. Test results for 8x12 SEATIMBER® components with 8.5-feet span

Test Number	Test Component	Maximum Load, kips (kN)	Deflection at Maximim Load, in (mm)	Failure Mode
48	SW-8x12-4F08-8.5_C1	39.7 (176)	4.0 (102)	Cracking sound-Internal crack
49	SW-8x12-4F08-8.5_C2	22.7 (125)	2.6 (160)	Cracking sound-Internal crack
50	SW-8x12-4F08-8.5_C3	32.1 (143)	5.4 (138)	Plastic/Glass bar Debonding
51	SW-8x12-4F08-8.5_C4	28.4 (127)	3.1 (80)	Plastic Rupture-External crack
52	SW-8x12-4F08-8.5_C5	38.4 (171)	4.9 (126)	Cracking sound-Internal crack
53	SW-8x12-4F08-8.5_C6	37.0 (165)	3.9 (99)	Cacking sound-Internal crack

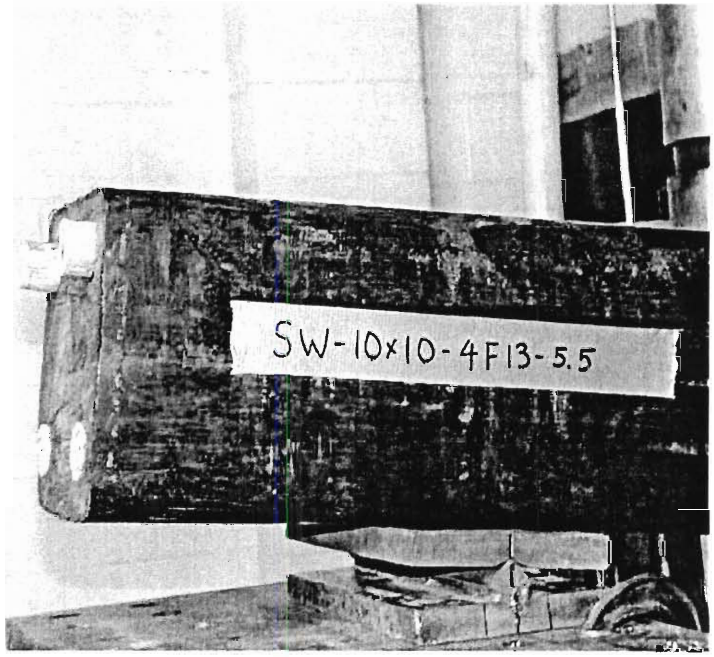


Figure 6. Plastic/Glass bar debonding of a SEATIMBER® component

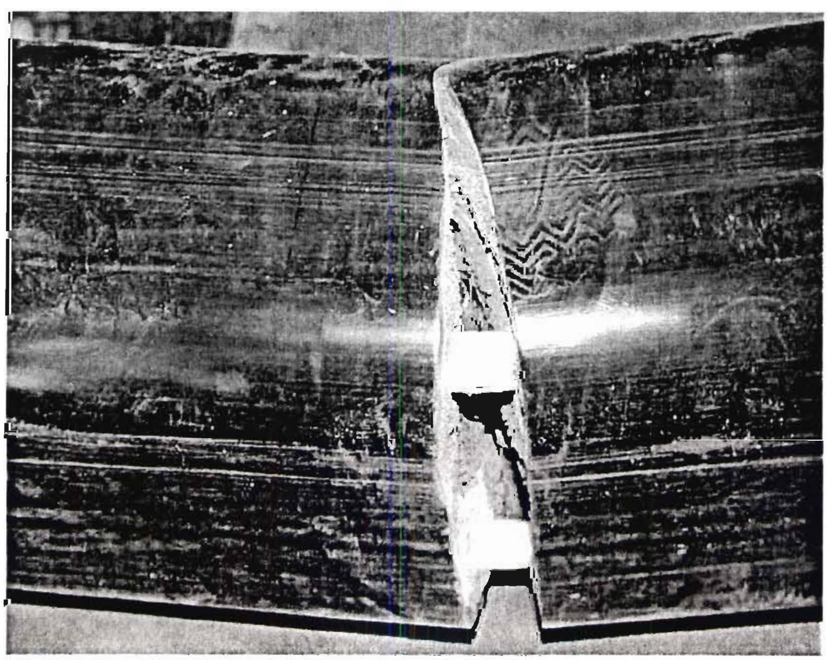


Figure 7. Plastic rupture-External crack failure mode of a SEATIMBER® component

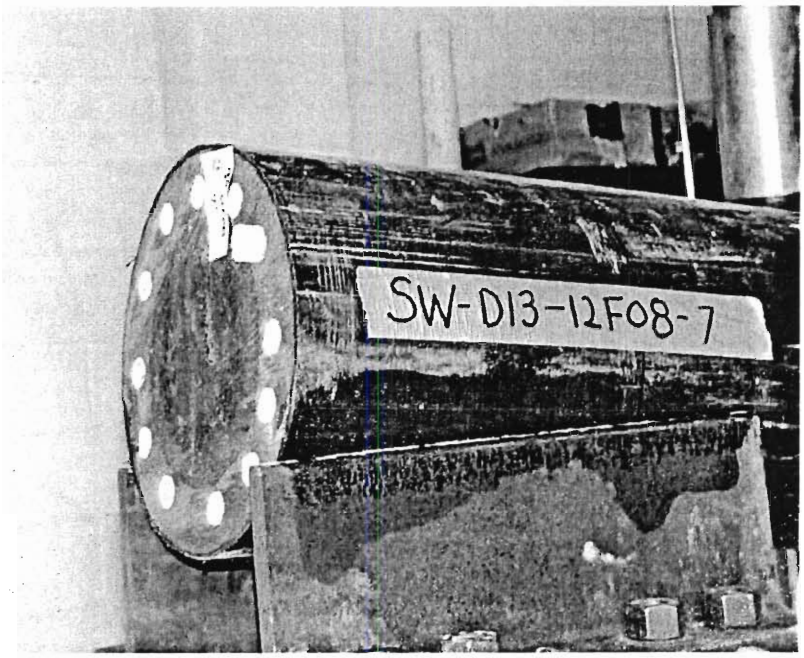


Figure 8. Plastic/Glass bar debonding failure mode of a SEAPILE® component

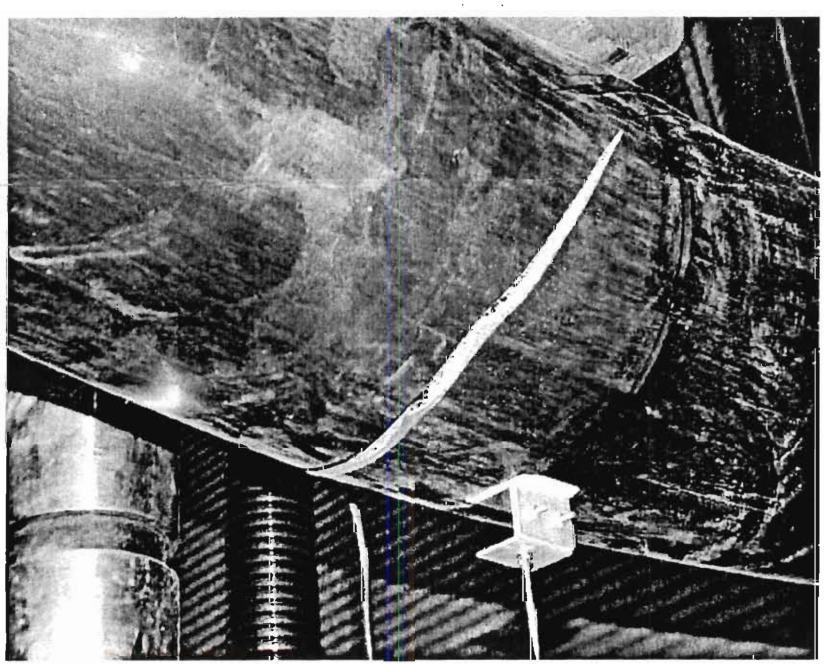


Figure 9. Plastic rupture failure of a SEAPILE® component

Flexural stiffness and shear stiffness properties for SEATIMBER® and SEAPILE® were investigated from test results. Deflection at the midspan of a simply supported beam subjected to to a center load P can be expressed in the form:

$$\delta = \frac{PL^3}{48D} + \frac{PL}{4Q} \tag{1}$$

This is rearranged as:

$$\frac{\delta}{PL} = \frac{1}{48D}L^2 + \frac{1}{4Q} \tag{2}$$

When a straight line is then fitted to the experimental data, the slope and the intercept of such a line represent $1/(48D)$ and $1/(4Q)$, respectively, and thus the flexural and shear stiffnesses D and Q can be determined readily. For all test components except those which were not reinforced with E-glass bars, the values of D and Q were computed at the deflection level corresponding to 1% pure bending strain estimated from:

$$\delta = \frac{\varepsilon L^2}{6h} = \frac{(0.01)L^2}{6h} \tag{3}$$

Computed stiffness values for SEATIMBER® and SEAPILE® components are summarized in Table 8. All the experimental data and regression curves used in the calculation are presented in Figures 10, 11, and 20.

Table 8. Computed flexural stiffness and shear stiffness

Test Component	Flexural Stiffness, D kips-in^2 (kN-m^2)	Shear Stiffness, Q kips (kN)
SW-10x10-4F08	334,000 (960)	1,620 (7,300)
SW-10x10-4F13	678,000 (1,950)	1,770 (7,900)
SW-12x12-4F08	553,000 (1,590)	4,200 (18,700)
SW-12x12-4F12	1,097,000 (3,150)	3,230 (14,400)
SW-12x8-4F08	112,000 (320)	1,530 (6,800)
SW-8x12-4F08	249,000 (710)	3,580 (15,900)
SW-12x8-4F13	212,000 (610)	960 (4,300)
SW-8x12-4F13	537,000 (1,540)	970 (4,300)
SW-D13-12F08	619,000 (1,780)	1,330 (5,900)
SW-D13-12F13	1,961,000 (5,630)	1,550 (6,900)

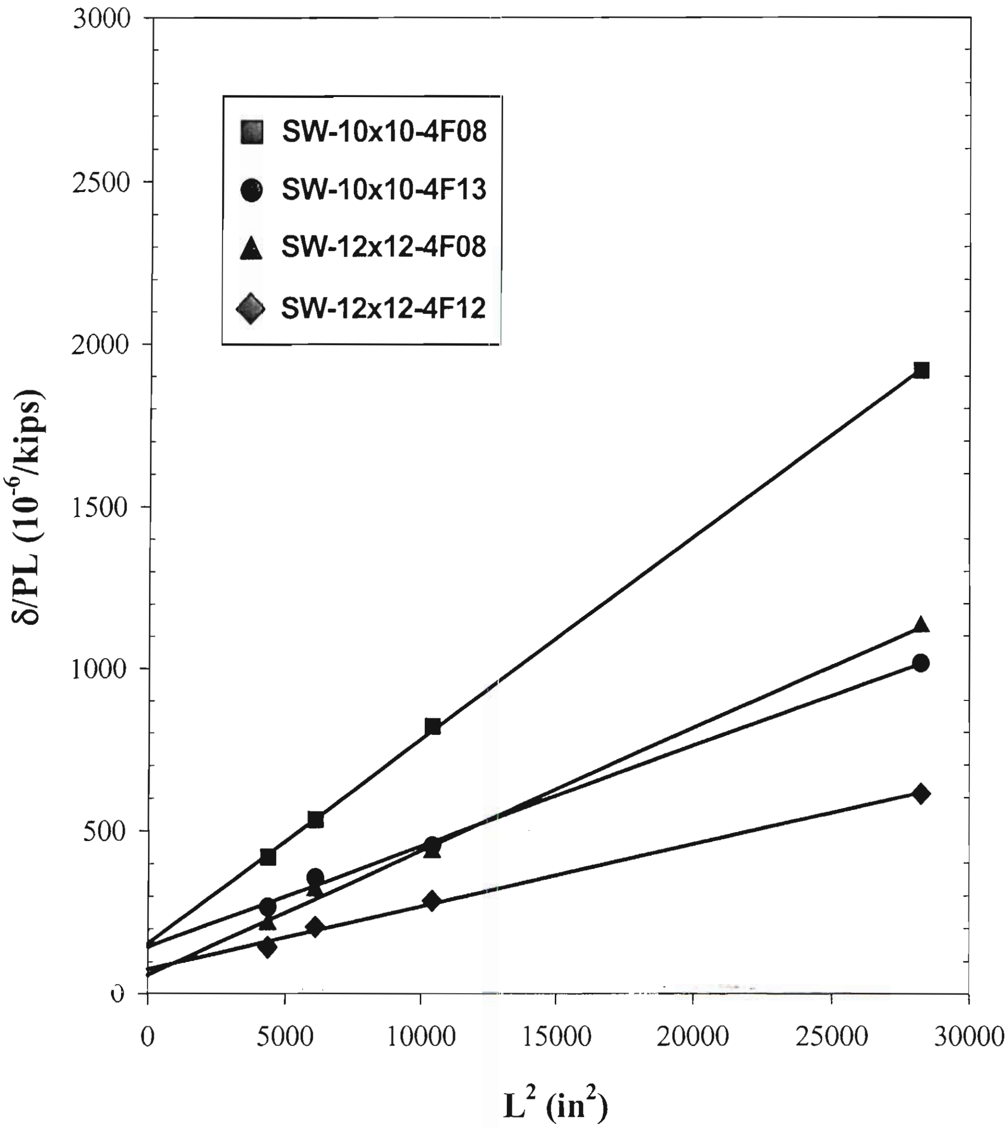


Figure 10. Experimental data and L^2 vs. δ/PL linear regression curves for square SEATIMBER® components

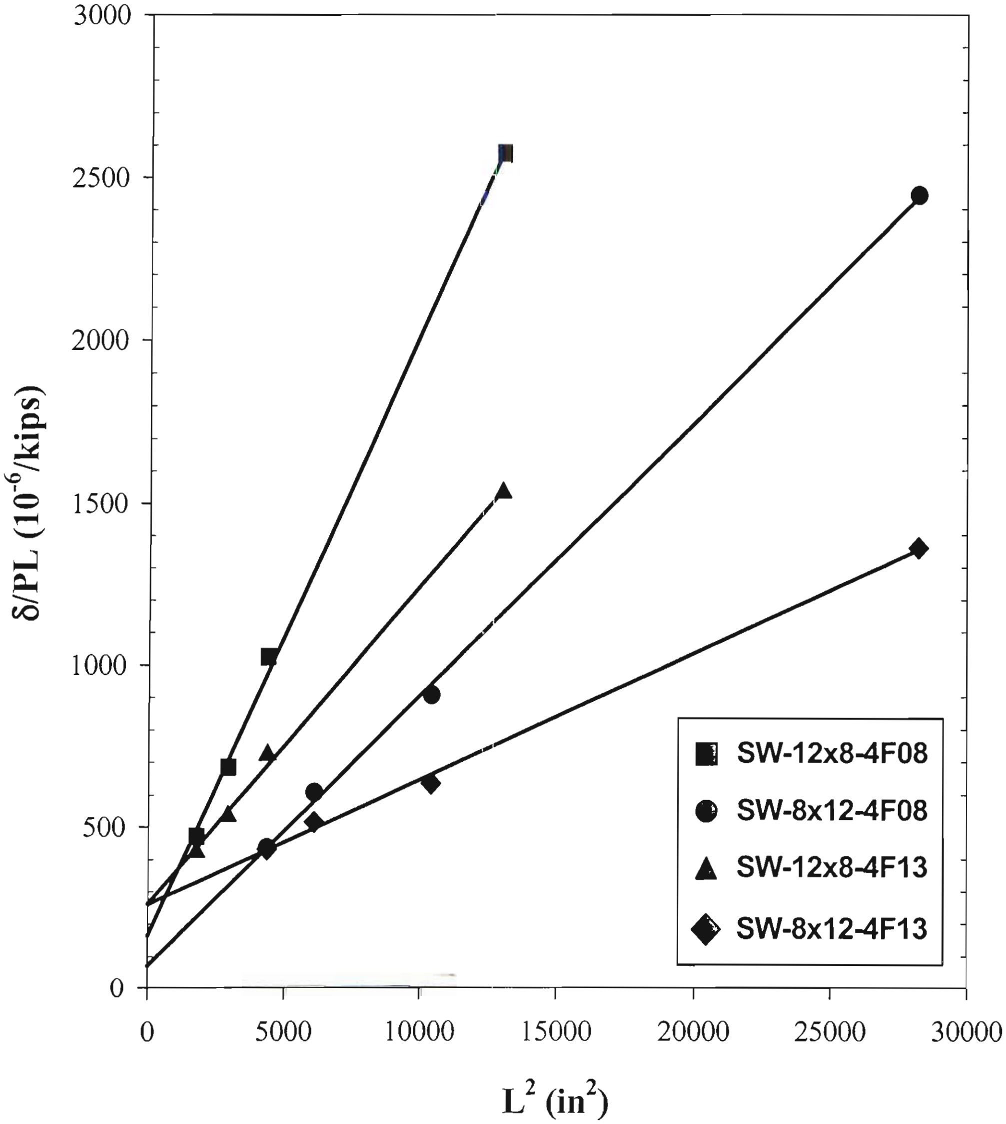


Figure 11. Experimental data and L^2 vs. δ/PL linear regression curves for for rectangular SEATIMBER® components

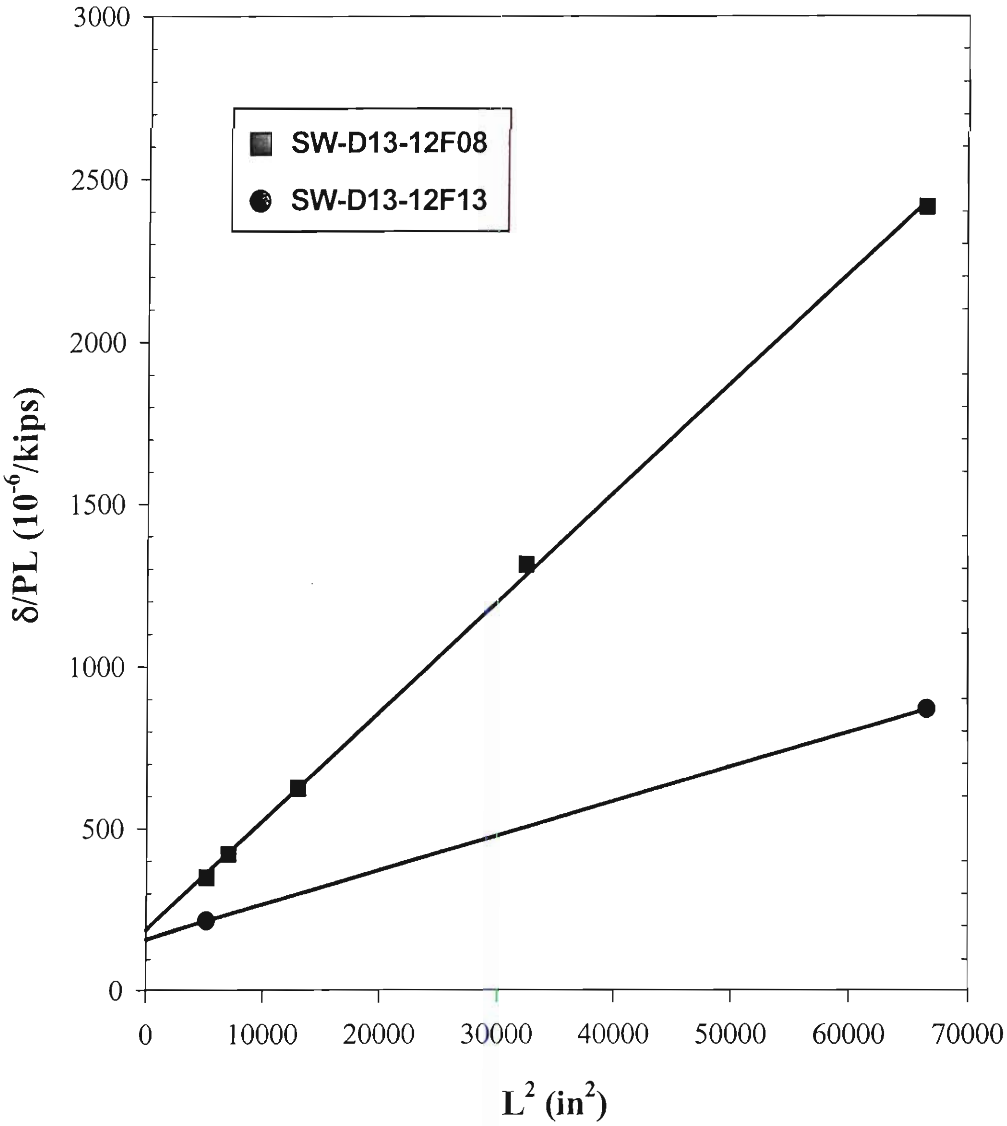


Figure 12. Relationships between L^2 and δ/PL for SEAPILE® components

TENSILE TESTS OF GLASS REINFORCING BARS

Tensile tests were conducted on nine 4-ft (1,090 mm) long E-glass bars; three tests on each of the No. 8, 10, and 13 bars. The two opposite ends of each bar were embedded into steel pipes filled with BRISTAR, an expansive cementious material. Each pipe had an outside diameter of 2.75-inches (70-mm), a length of 12-inches (304-mm) and a wall thickness of 0.25 inches (6 mm). A schematic showing the glass bar with the end anchors is shown in Figure 13. All end anchors were prepared in the wood frame shown inFigure 14. These pipe anchors served as an interface between the glass bars and the grips of the testing machine. A close up photo of the pipe anchor filled with BRISTAR is shown in Figure 15. Each test specimen was aligned in the testing machine with the dial gage extensometer, shown in Figure 16, mounted on bar at mid-height as shown in Figure 18. The load was applied at the rate of 0.2 in./minute (5 mm/minute) until failure occured. Photographs of a failed bar are shown in Figures 18 and 19. The strain was calculated by dividing the extensometer displacement at each reading by the gage length. The modulus was computed by from the slope of of a line obtained from a linear regression of the experimental data between 0.1% and 0.3% strain. The ultimate strength was defined as the maximum load attained prior to failure of the bar. The modulus and strength of each tested bar are given in Table 9 with the stress-strain curves shown in Figure 20.

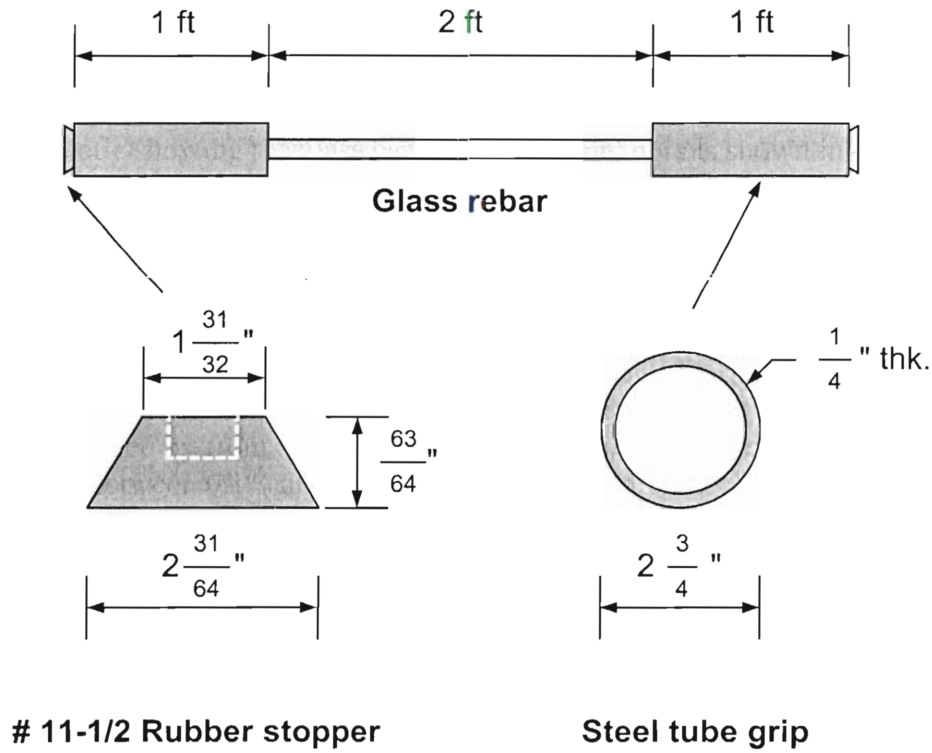


Figure 13. A glass bar with end anchors

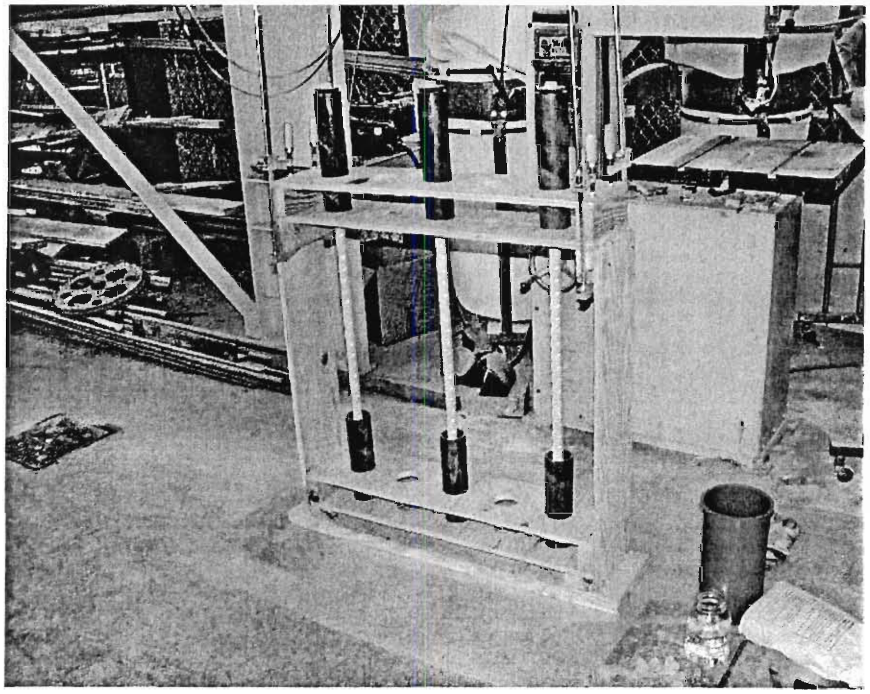


Figure 14. A wood frame for end anchoring

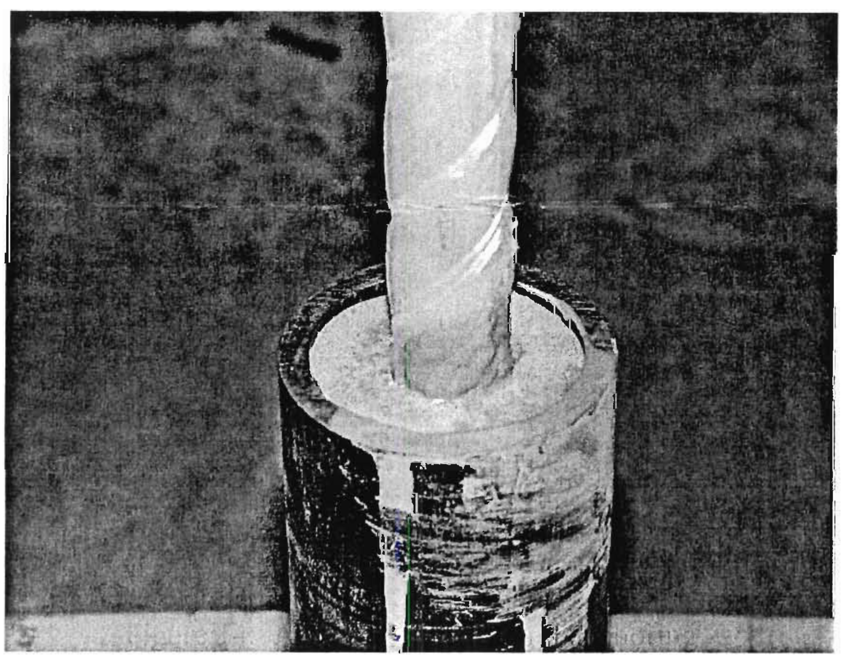


Figure 15. Steel pipe anchor

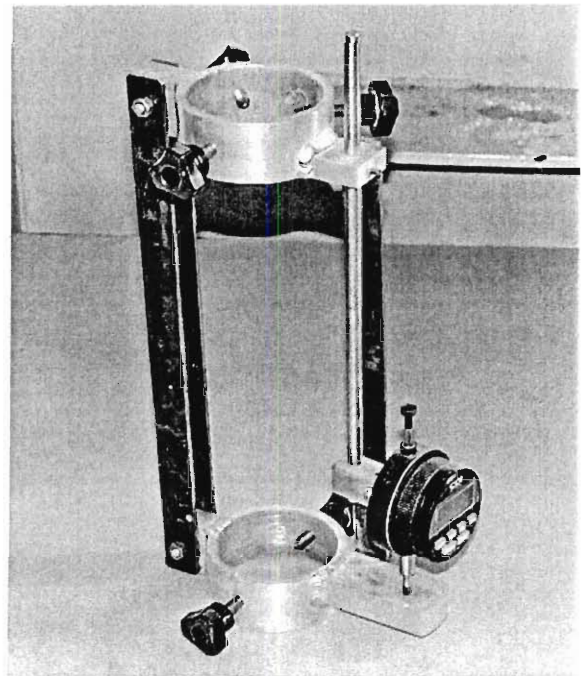


Figure 16. Dial gage extensometer

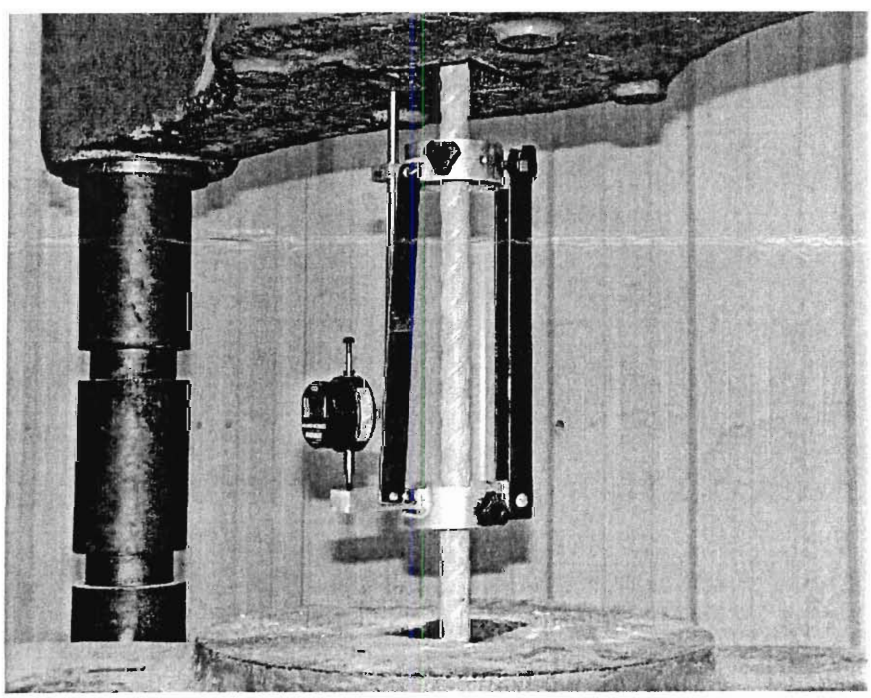


Figure 17. Glass bar in the testing machine

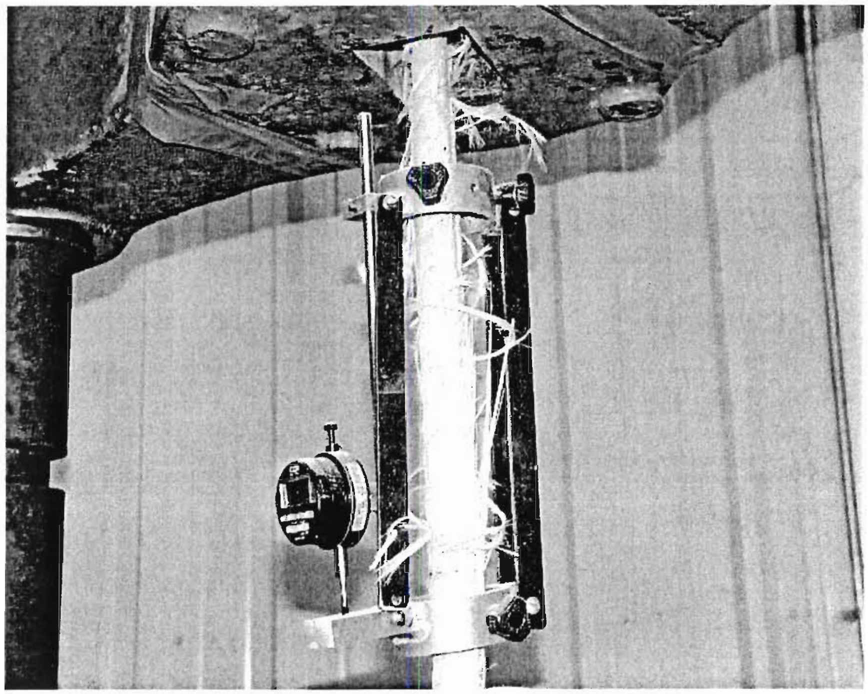


Figure 18. Typical failure of a glass bar

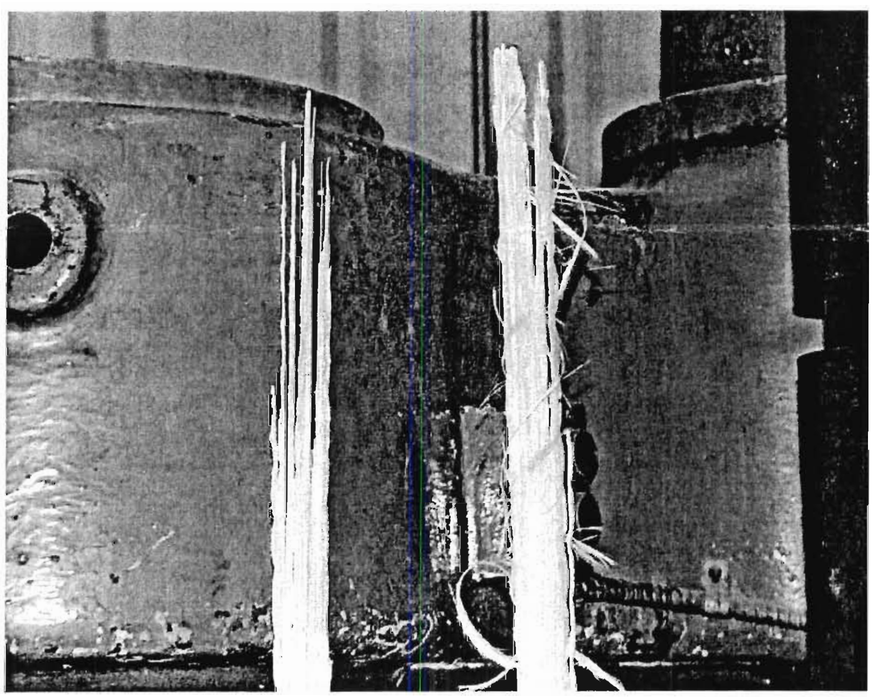


Figure 19. Close up photo of the failure of a glass bar

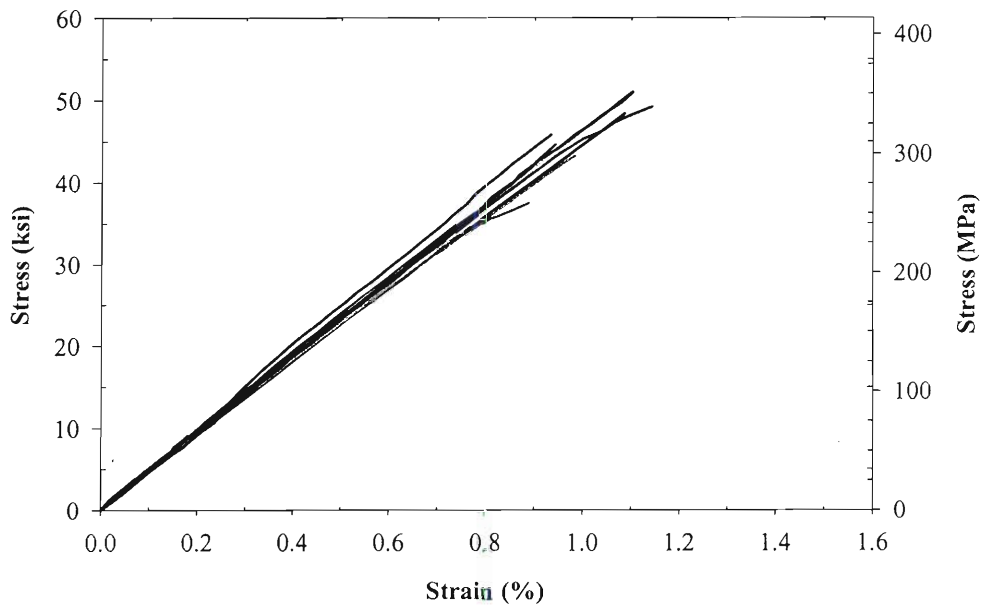


Figure 20. Stress-strain curves of glass rebars

Table 9. Glass bar tensile modulus and strength

Specimen	Tensile Modulus ksi (MPa)	Tensile Strength ksi (MPa)
GL08-01	4,480 (30,900)	53.6 (370)
GL08-02	4,720 (32,600)	54.9 (378)
GL08-03	4.650 (32,100)	51.7 (356)
Average	**4,620 (31,800)**	**53.4 (368)**
GL10-01	4,560 (31,500)	54.2 (374)
GL10-02	4,540 (31,300)	46.0 (317)
GL10-03	4,520 (31,200)	43.9 (303)
Average	**4,540 (31,300)**	**48.1 (331)**
GL13-01	4,560 (31,400)	50.1 (346)
GL13-02	5,070 (35,000)	46.8 (322)
GL13-03	4,510 (31,100)	45.6 (314)
Average	**4,710 (32,500)**	**47.5 (341)**
Total Average	**4,620 (31,900)**	**49.6 (342)**
C. O. V. (%)	4.0	8.4

APPENDIX

Table A-1. Measured dimensions of "as received" SEATIMBER® components

Specimen	Width (in)	Height (in)	Distance from the center of E-Glass bar to the surface			
			Top (in)	Bottom (in)	Front (in)	Back (in)
SW-10x10-0F0-5.5	10.03	9.99	N/A	N/A	N/A	N/A
SW-10x10-0F0-6.5	10.00	10.00	N/A	N/A	N/A	N/A
SW-10x10-0F0-8.5	10.19	10.07	N/A	N/A	N/A	N/A
SW-10x10-0F0-14	10.12	10.01	N/A	N/A	N/A	N/A
SW-10x10-4F08-5.5	9.77	9.85	1.88	2.06	2.03	2.02
SW-10x10-4F08-6.5	9.76	9.74	2.04	1.96	1.91	2.04
SW-10x10-4F08-8.5	9.73	9.79	1.88	1.98	2.03	1.90
SW-10x10-4F08-14	9.77	9.80	2.05	1.83	1.90	1.97
SW-10x10-4F13-5.5	9.80	9.75	1.81	1.96	1.92	1.89
SW-10x10-4F13-6.5	9.77	9.82	1.83	1.95	2.22	1.70
SW-10x10-4F13-8.5	9.75	9.75	2.02	1.76	1.94	1.84
SW-10x10-4F13-14	9.97	9.77	2.14	1.72	2.06	1.85
SW-12x12-4F08-5.5	11.81	11.81	2.39	2.19	2.44	2.00
SW-12x12-4F08-6.5	11.81	11.84	2.16	2.23	2.10	2.00
SW-12x12-4F08-8.5	11.83	11.78	2.28	2.02	2.23	2.34
SW-12x12-4F08-14	11.79	11.82	2.41	2.09	1.90	2.44
SW-12x12-4F12-5.5	11.81	11.80	1.99	2.03	2.33	2.06
SW-12x12-4F12-6.5	11.76	11.80	2.06	1.73	2.44	1.93
SW-12x12-4F12-8.5	11.82	11.87	1.86	2.38	2.01	1.86
SW-12x12-4F12-14	11.85	11.78	1.98	1.99	2.10	2.36
SW-12x8-4F08-3.5	11.98	8.04	1.59	1.88	2.38	2.41
SW-12x8-4F08-4.5	11.98	7.98	1.61	1.95	2.39	2.28
SW-12x8-4F08-5.5	11.99	8.02	1.70	1.99	2.40	2.35
SW-12x8-4F08-9.5	12.02	7.99	1.96	1.86	2.15	2.23
SW-8x12-4F08-5.5	7.95	11.99	2.32	2.32	1.91	1.67
SW-8x12-4F08-6.5	7.99	12.00	2.28	2.35	1.66	1.94
SW-8x12-4F08-8.5	7.99	12.01	2.25	2.43	1.85	1.65
SW-8x12-4F08-14	8.06	12.05	2.35	2.38	1.59	1.90
SW-12x8-4F13-3.5	12.02	8.05	1.80	1.72	2.25	2.45
SW-12x8-4F13-4.5	12.06	8.05	1.85	1.72	2.30	2.39
SW-12x8-4F13-5.5	12.26	8.03	1.78	1.71	2.33	2.37
SW-12x8-4F13-9.5	12.08	8.07	1.71	1.86	2.33	2.48
SW-8x12-4F13-5.5	8.09	12.07	2.26	2.45	1.71	1.74
SW-8x12-4F13-6.5	8.05	12.31	2.36	2.50	1.77	1.86
SW-8x12-4F13-8.5	8.06	12.21	2.44	1.79	1.81	1.85
SW-8x12-4F13-14	10.07	10.08	2.27	2.43	1.75	2.04

Table A-2. Measured dimensions of “as received” SEAPILE® components

Specimen	Diameter (in)	Distance from the center of E-Glass bar to the surface (in)
SW-D13-12F08-6	12.95	1.79
SW-D13-12F08-7	12.95	1.80
SW-D13-12F08-9.5	12.97	1.74
SW-D13-12F08-15	12.98	1.82
SW-D13-12F08-21.5	12.75	1.62
SW-D13-12F13-6	13.11	1.32
SW-D13-12F13-21.5	13.04	1.39

Table A-3. Measured dimensions of “as received” Southern Yellow Pine (S.Y. Pine) and Type-P components

Specimen	Width (in)	Height (in)
SY-10x10-5.5	9.84	9.68
SY-10x10-6.5	9.83	9.87
SY-10x10-14	9.93	9.94
P-9x9-6.5	8.81	8.97

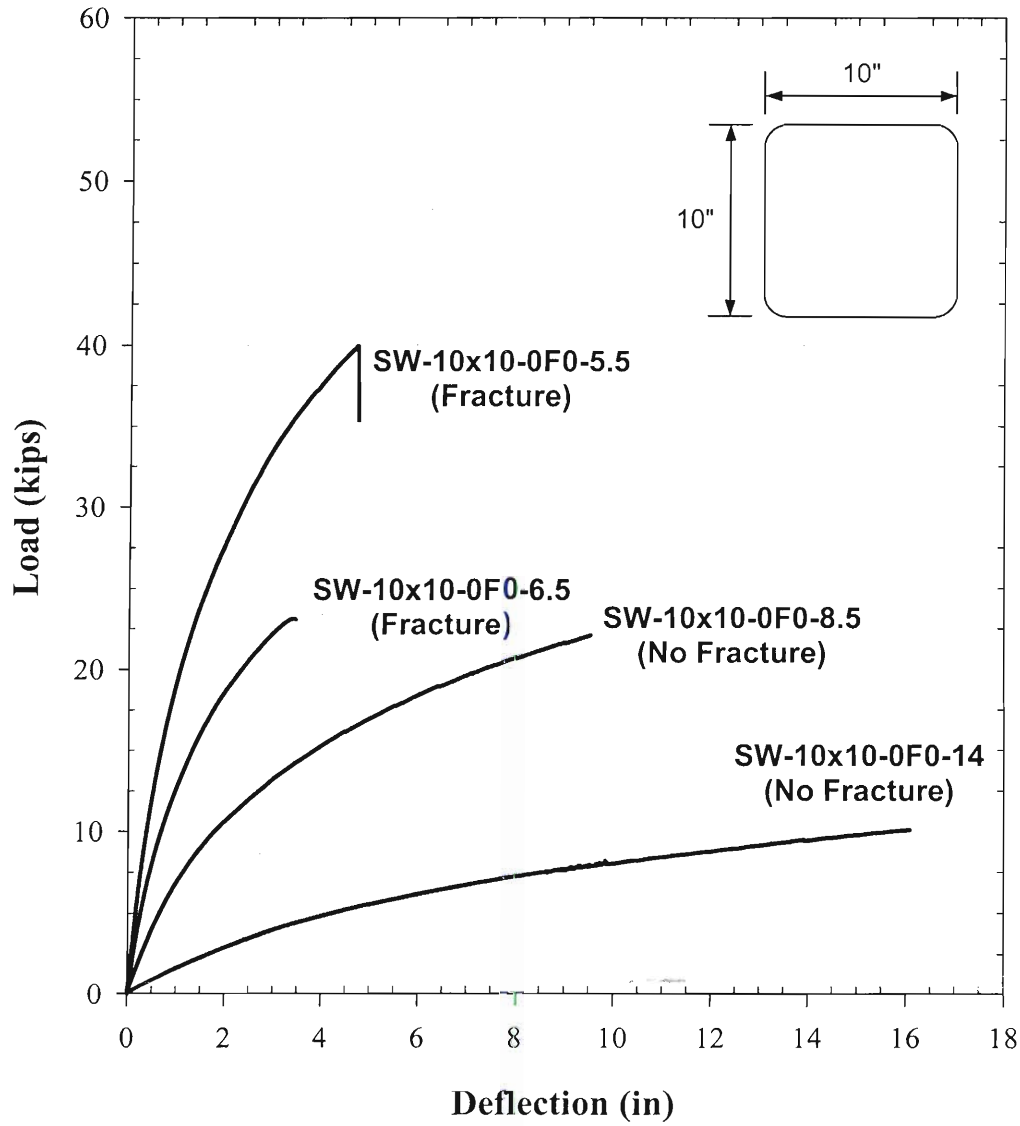


Figure A-1. Load-deflection curves of 10x10 unreinforced SEATIMBER® components

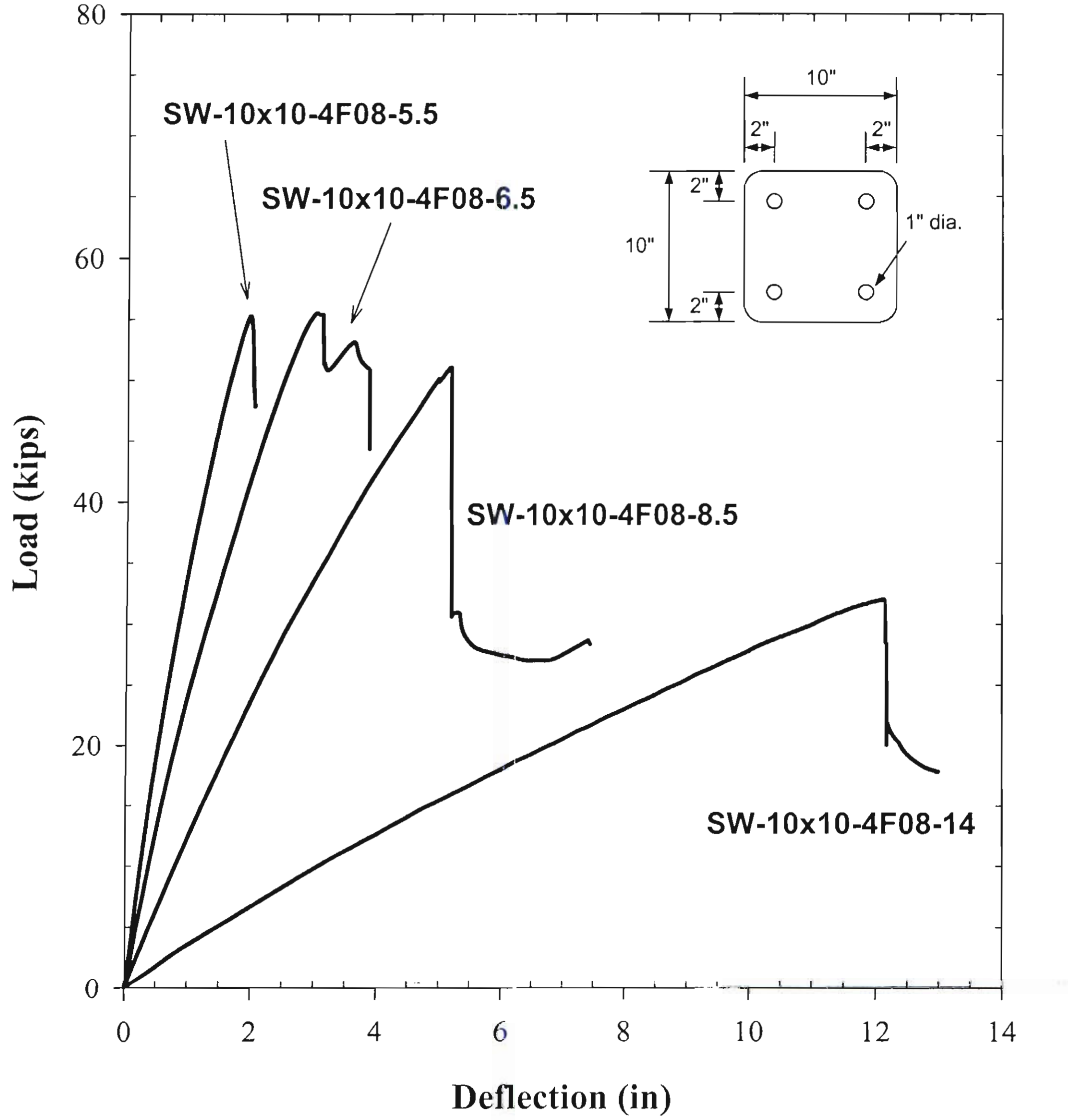


Figure A-2. Load-deflection curves of 10x10 SEATIMBER® components reinforced with four 1-inch diameter E-glass bars

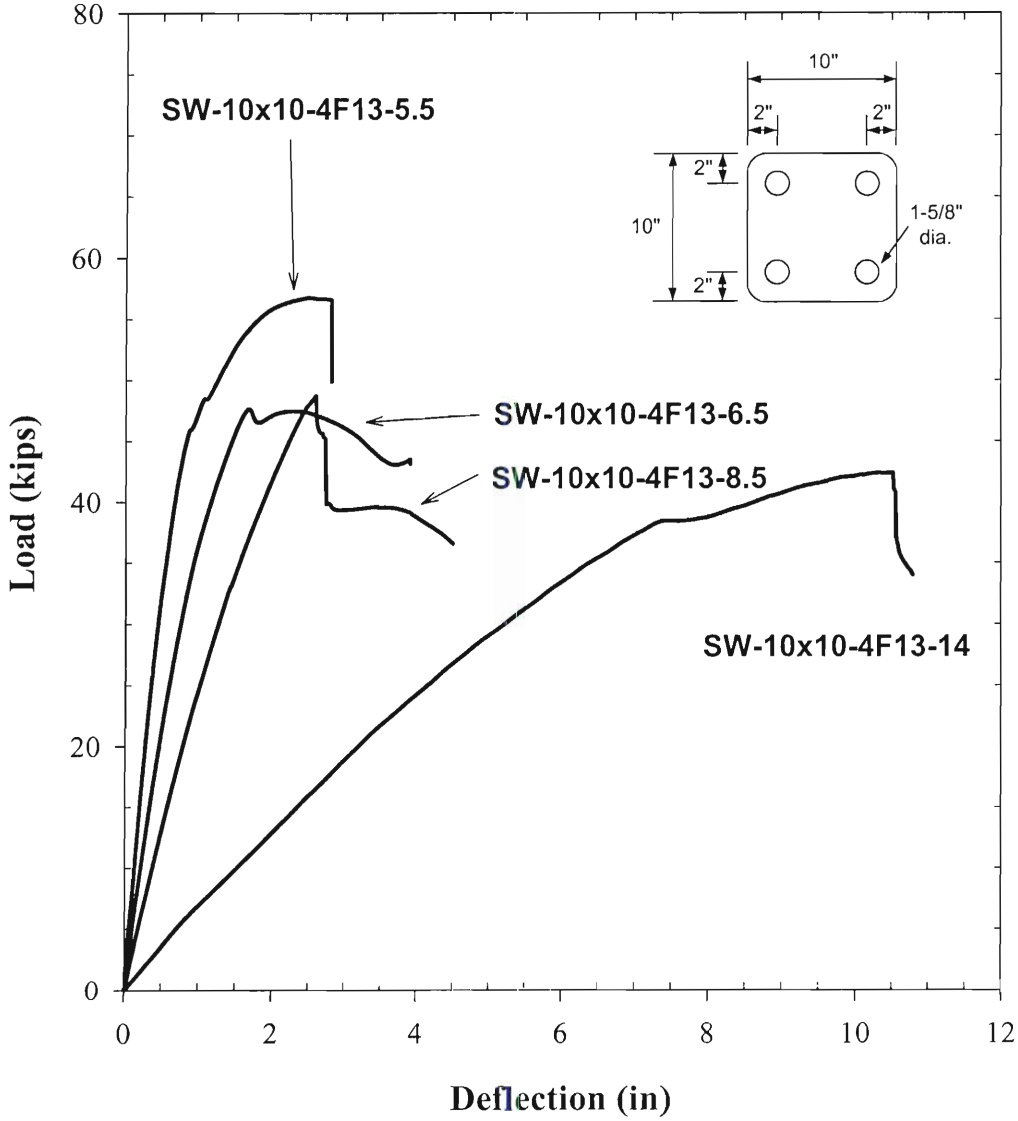


Figure A-3. Load-deflection curves of 10x10 SEATIMBER® components reinforced with four 1-5/8-inch diameter E-glass bars

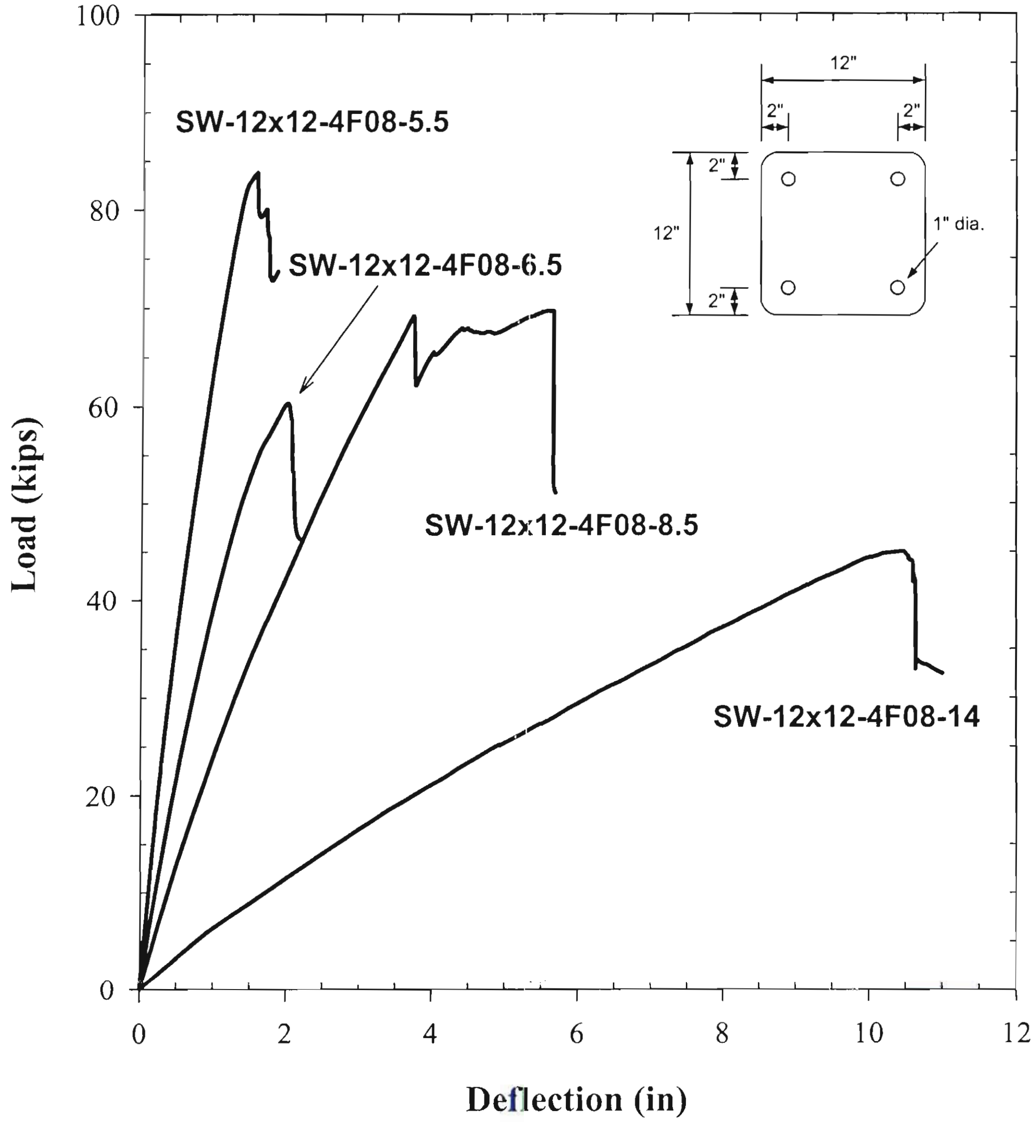


Figure A-4. Load-deflection curves of 12x12 SEATIMBER® components reinforced with four 1-inch diameter E-glass bars

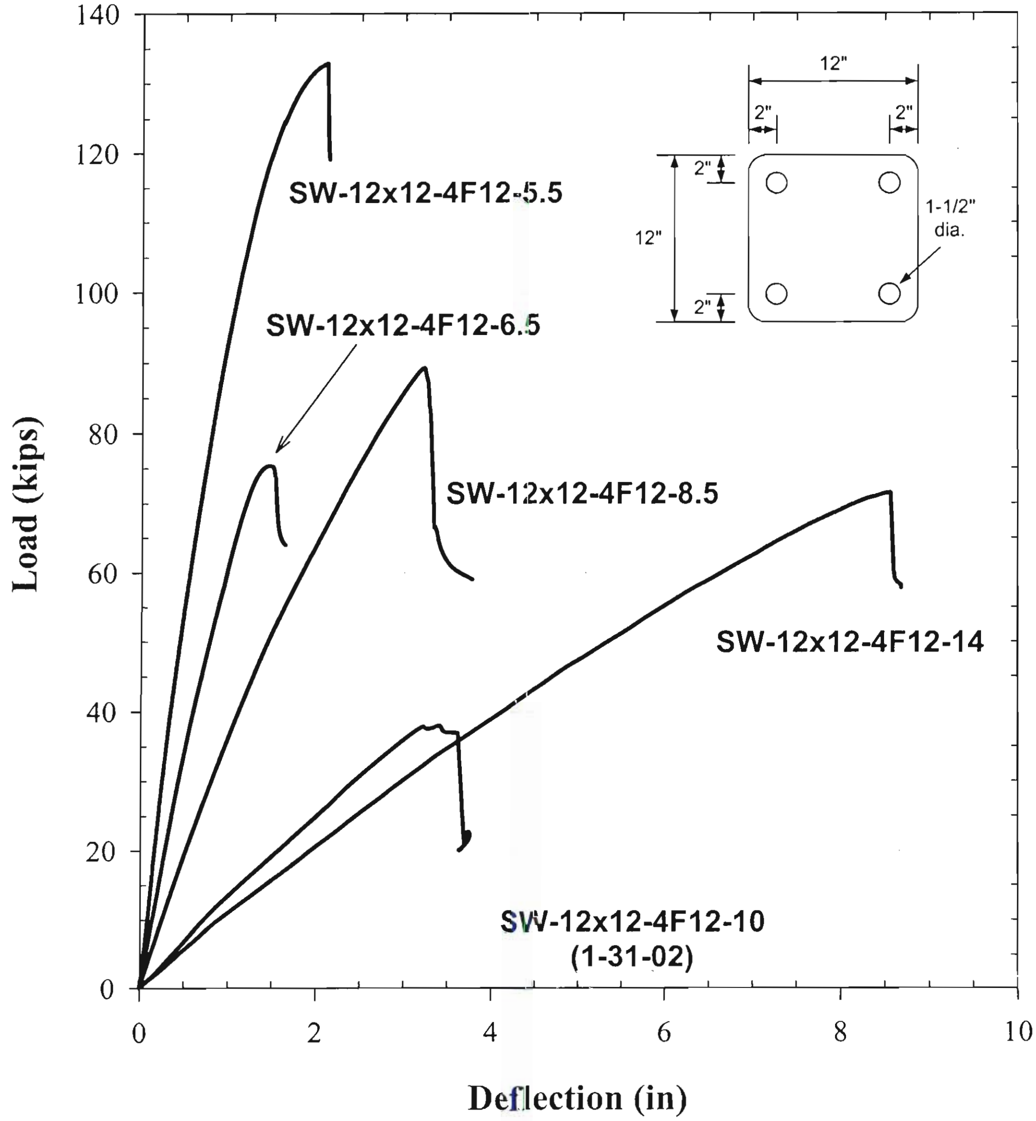


Figure A-5. Load-deflection curves of 12x12 SEATIMBER® components reinforced with four 1-1/2-inch diameter E-glass bars

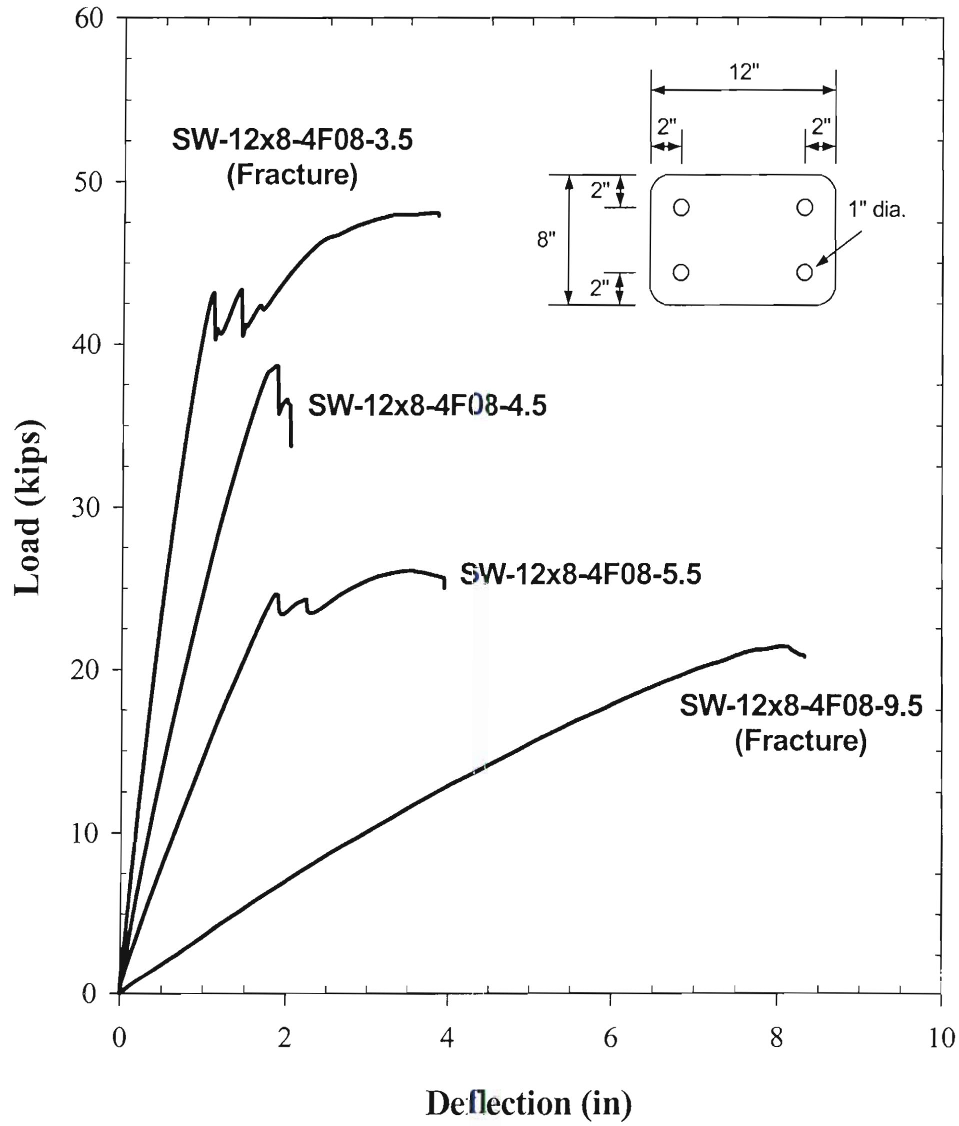


Figure A-6. Load-deflection curves of 12x8 SEATIMBER® components (weak axis) reinforced with four 1-inch diameter E-glass bars

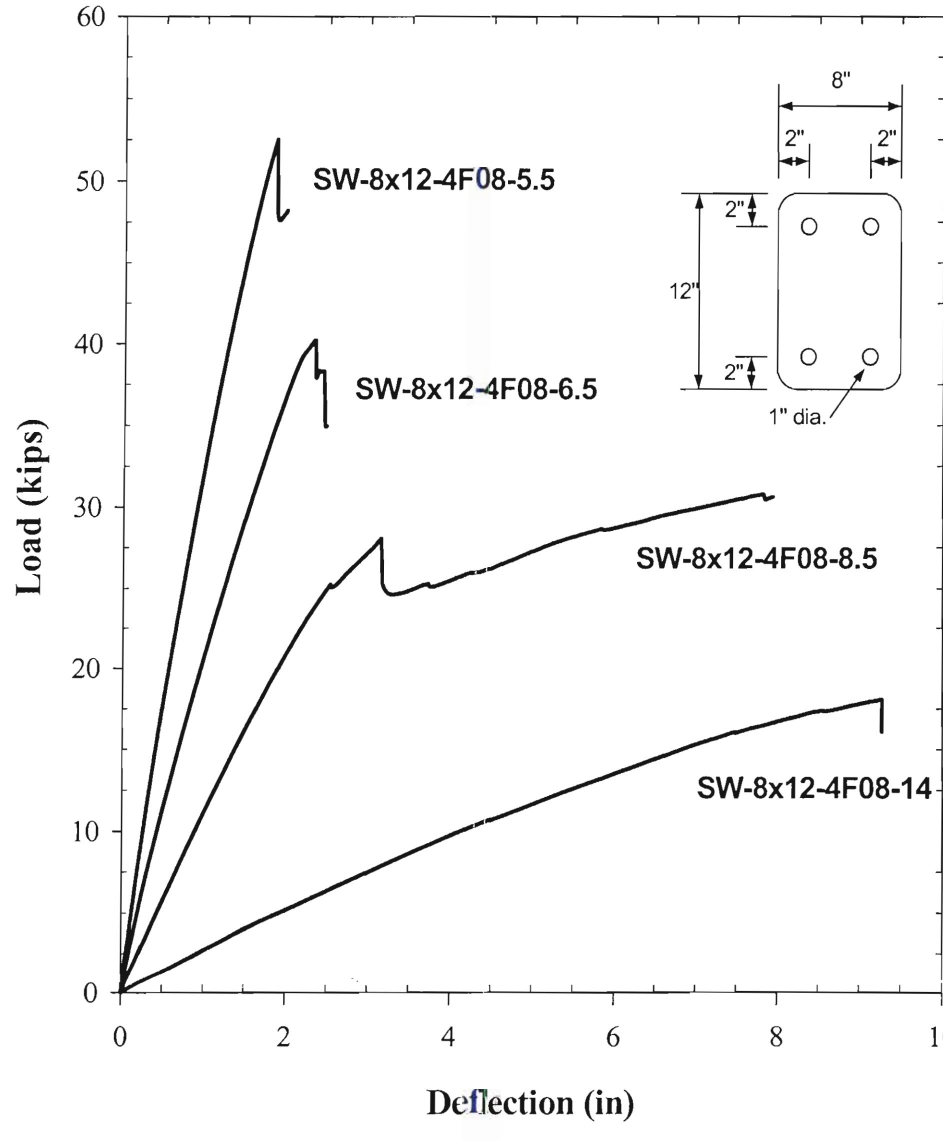


Figure A-7. Load-deflection curves of 8x12 SEATIMBER® components (strong axis) reinforced with four 1-inch diameter E-glass bars

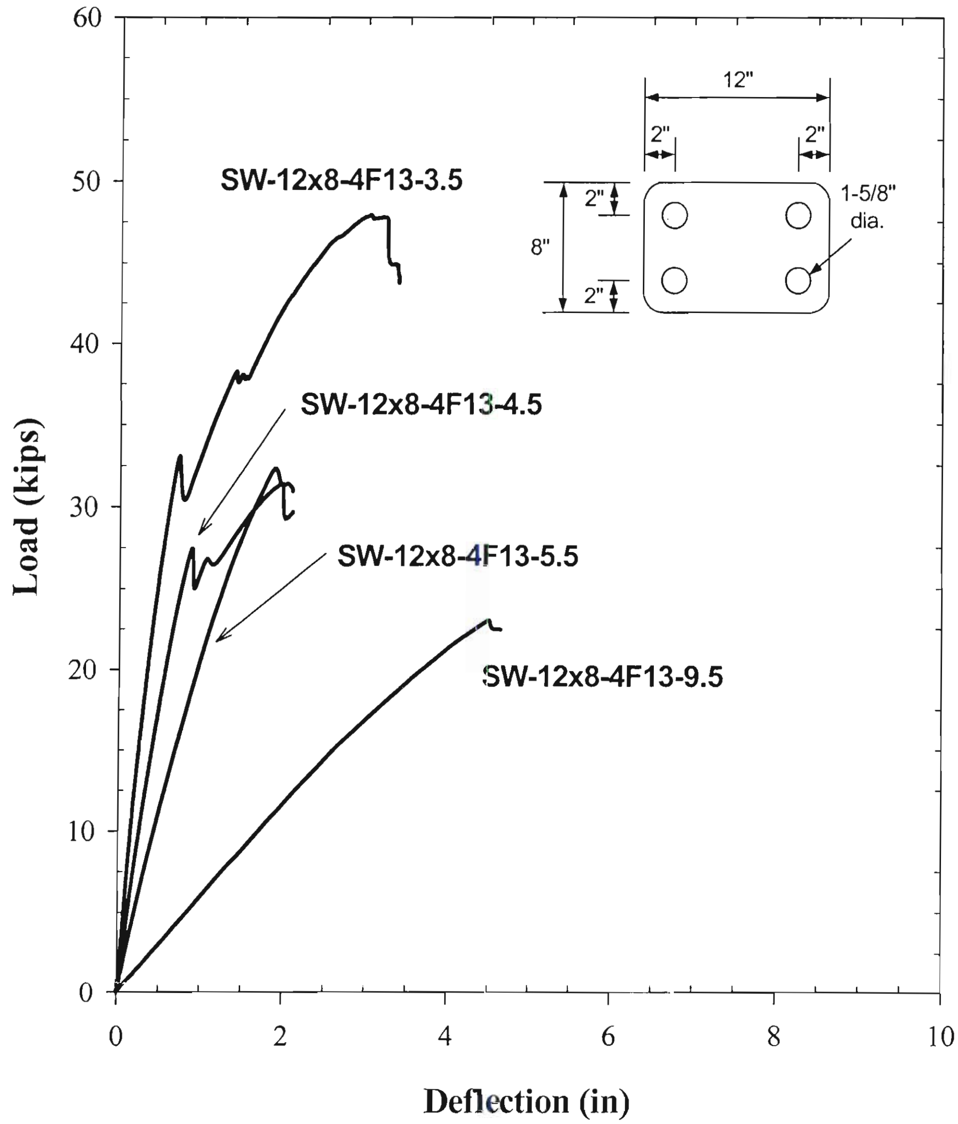


Figure A-8. Load-deflection curves of 12x8 SEATIMBER® components (weak axis) reinforced with four 1-5/8-inch diameter E-glass bars

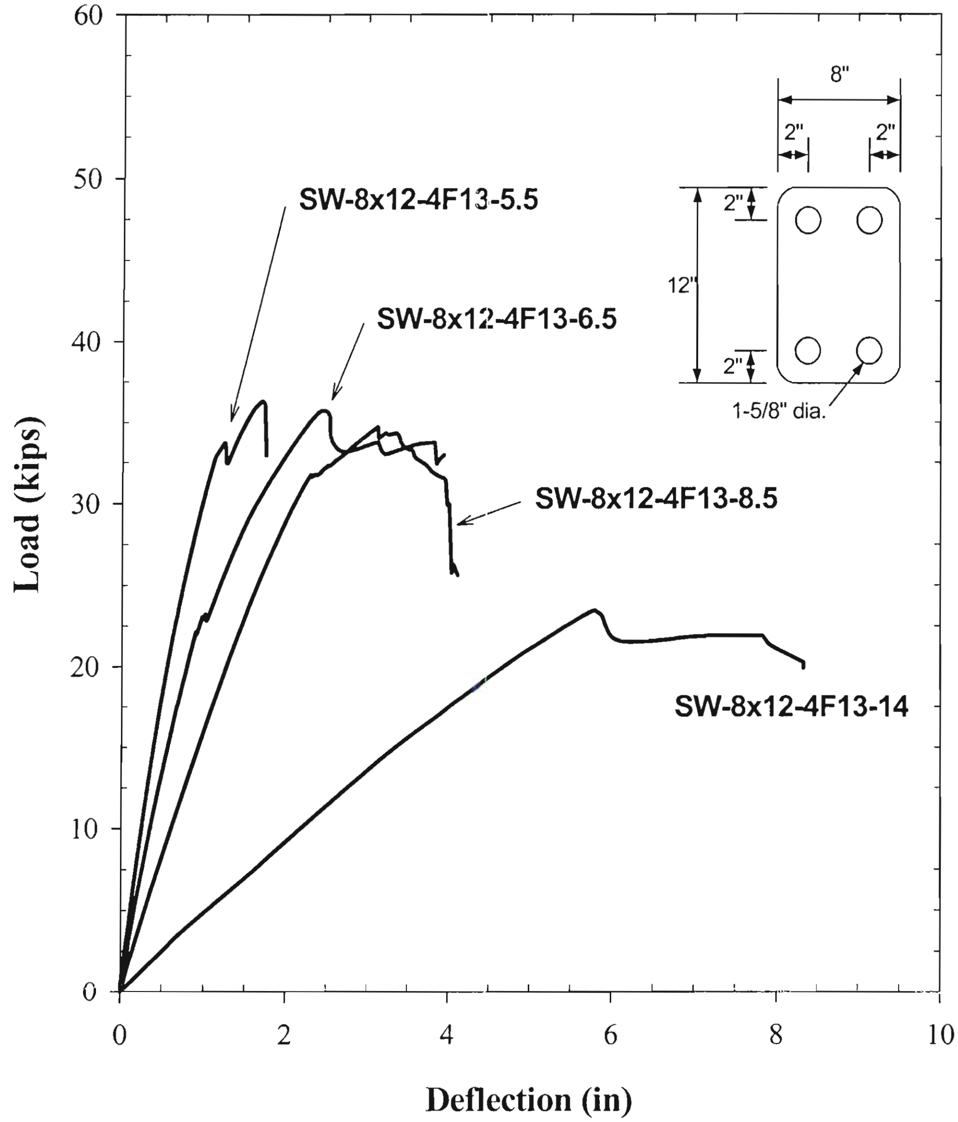


Figure A-9. Load-deflection curves of 8x12 SEATIMBER® components (strong axis) reinforced with four 1-5/8-inch diameter E-glass bars

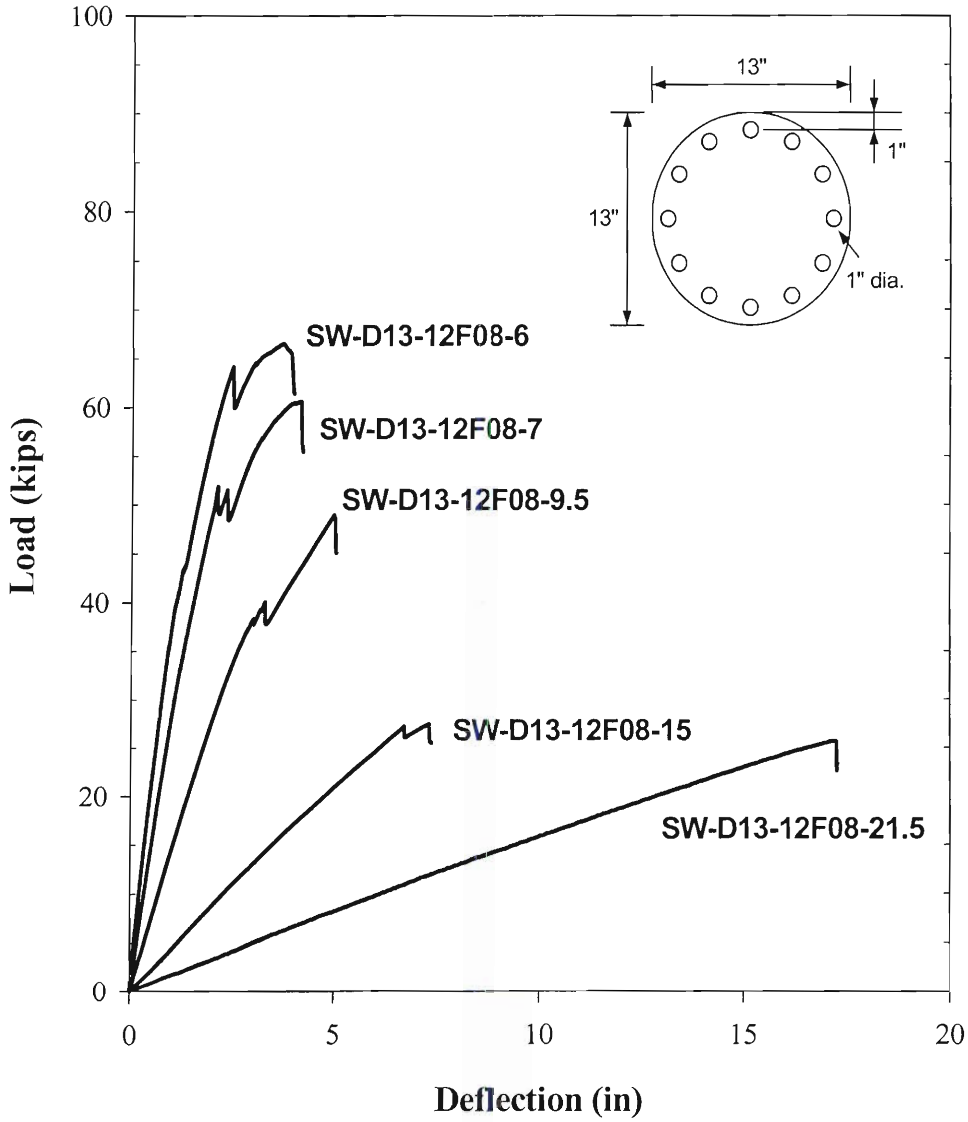


Figure A-10. Load-deflection curves of 13-inch diameter SEAPILE® components reinforced with twelve 1-inch E-glass bars

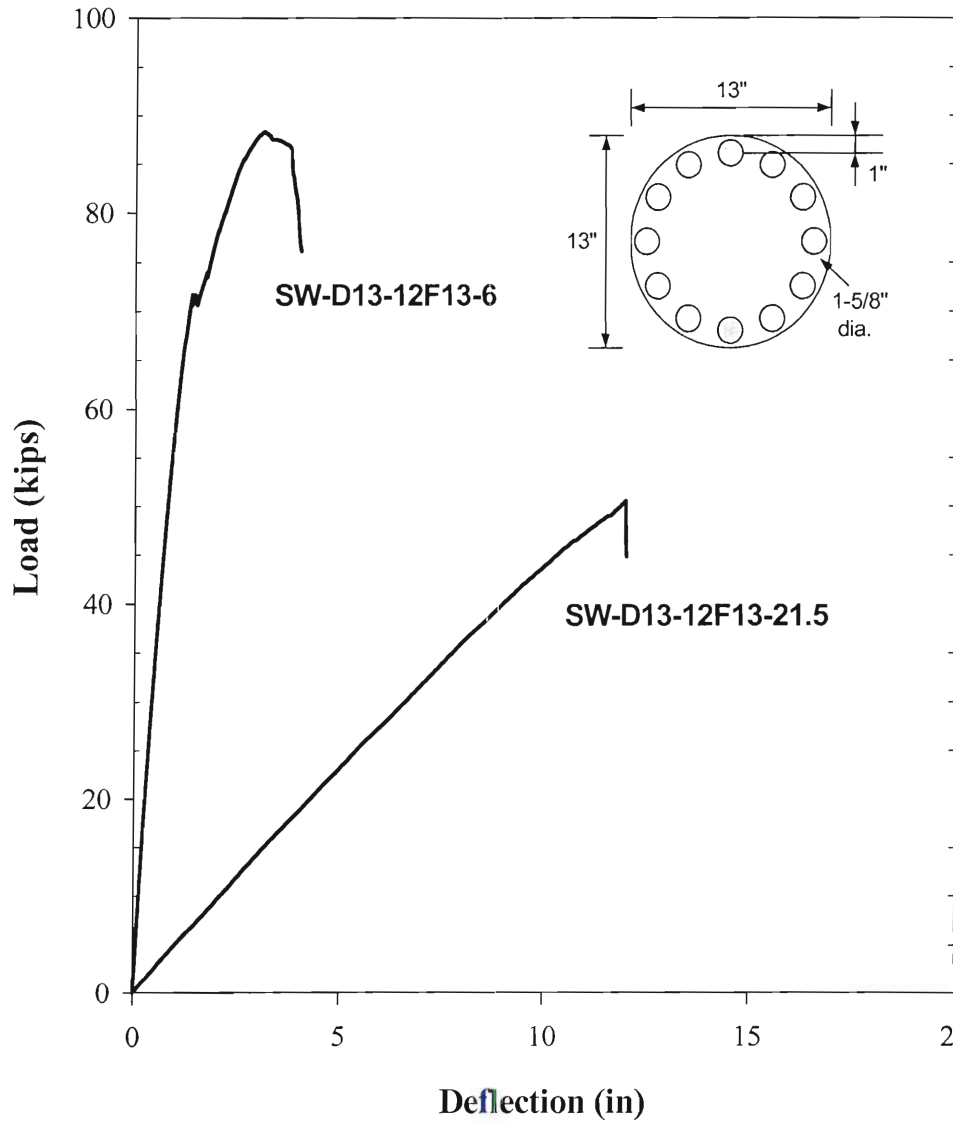


Figure A-11. Load-deflection curves of 13-inch diameter SEAPILE® components reinforced with twelve 1-5/8-inch E-glass bars

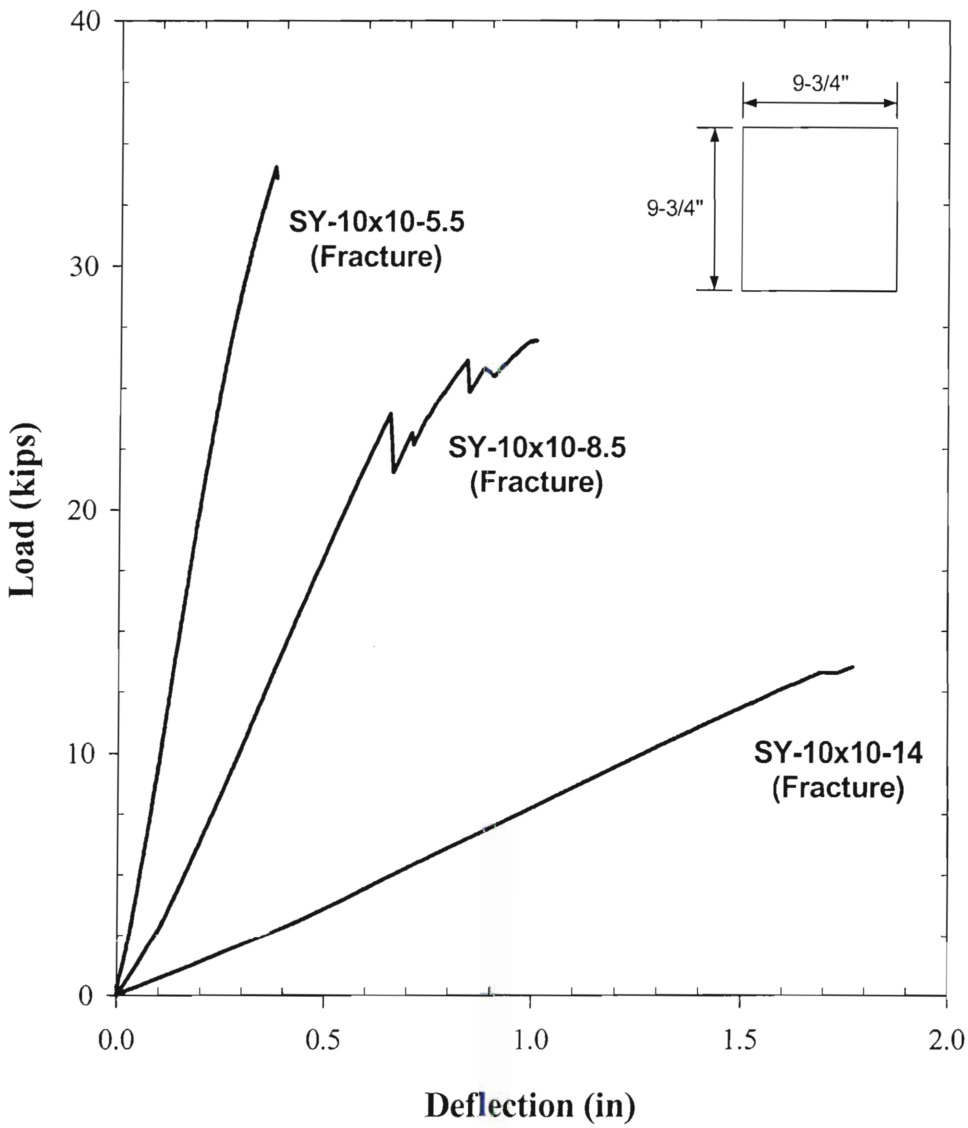


Figure A-12. Load-deflection curves of 10x10 S.Y. Pine wood components

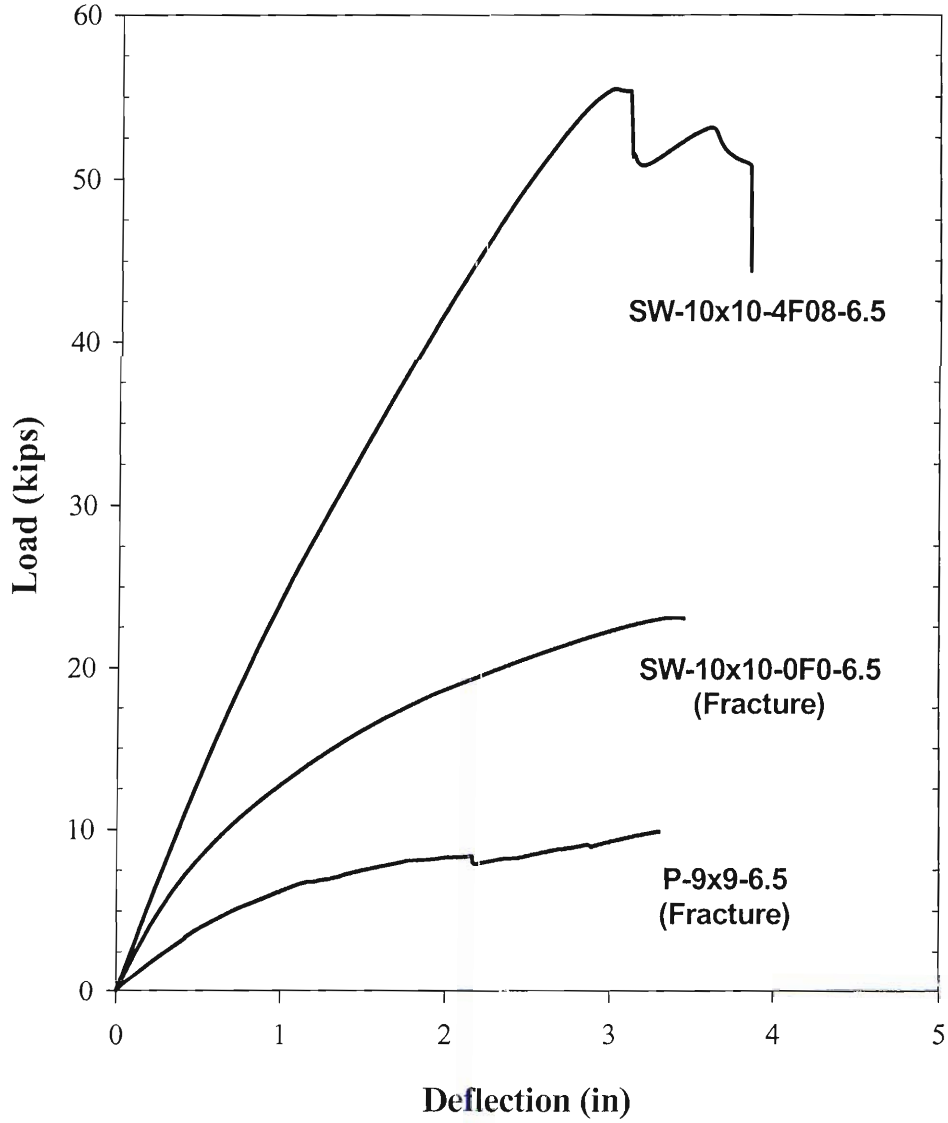


Figure A-13. Comparison of load-deflection curves of SEATIMBER® components and Type-P component

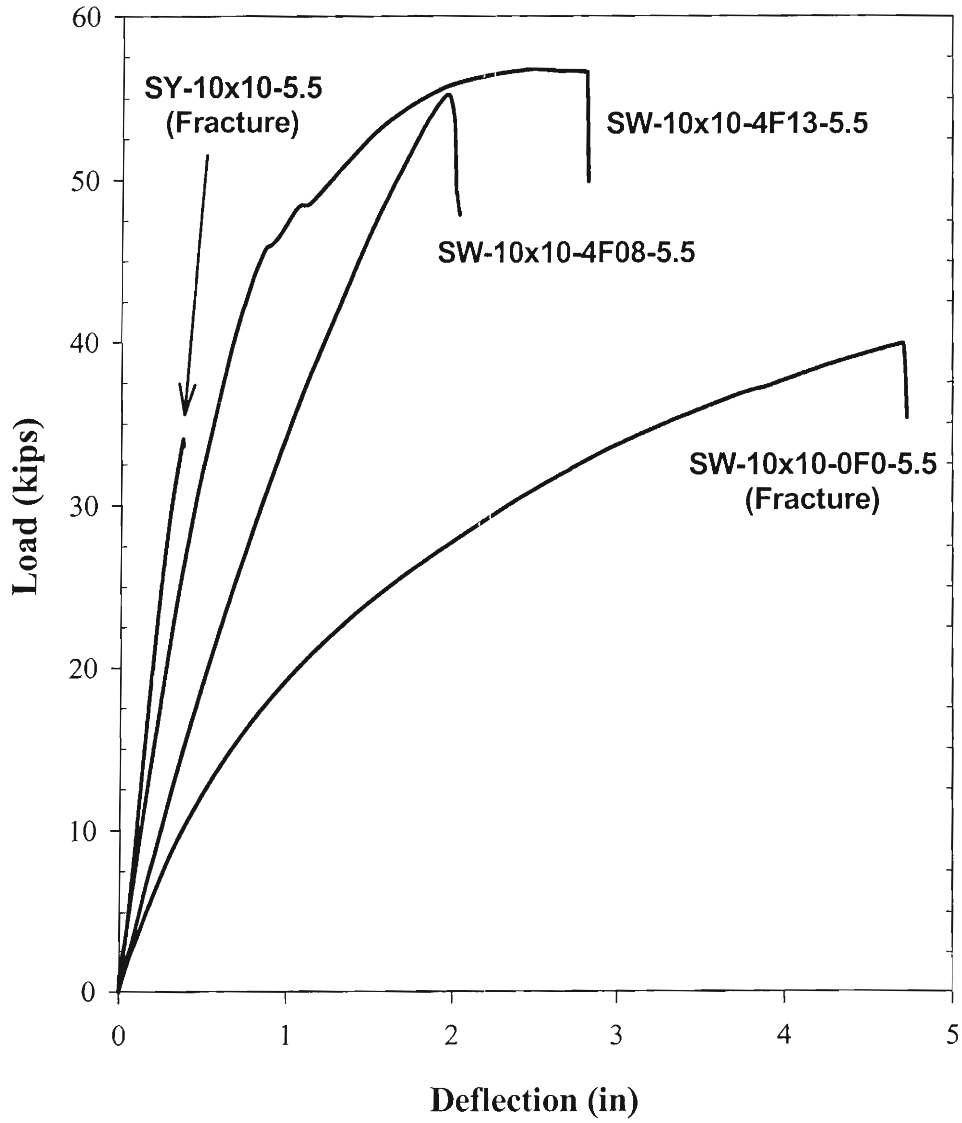


Figure A-14. Comparison of load-deflection curves of 10x10 SEATIMBER® components and S.Y. Pine wood component

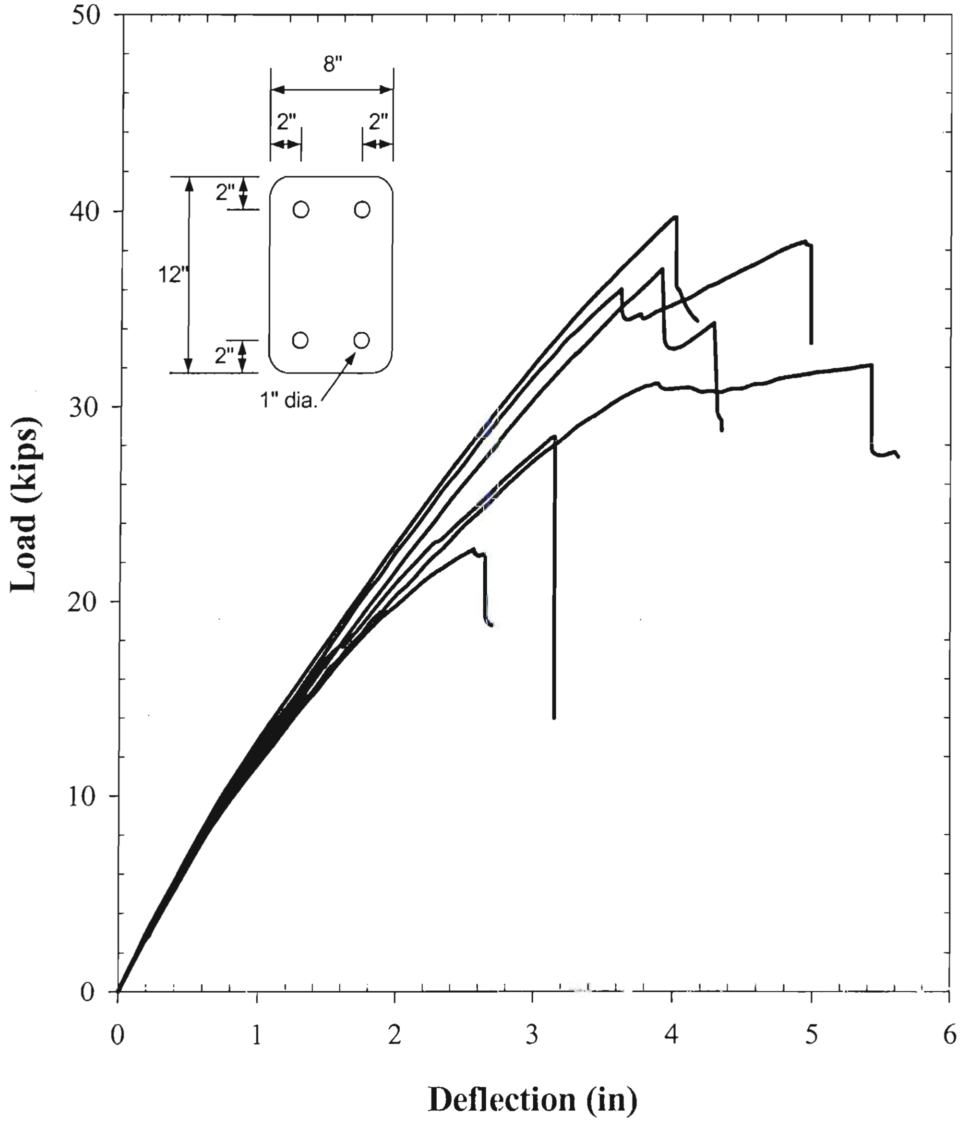


Figure A-15. Comparison of load-deflection curves of 8x12 SEATIMBER® components (strong axis) with 8.5-feet span

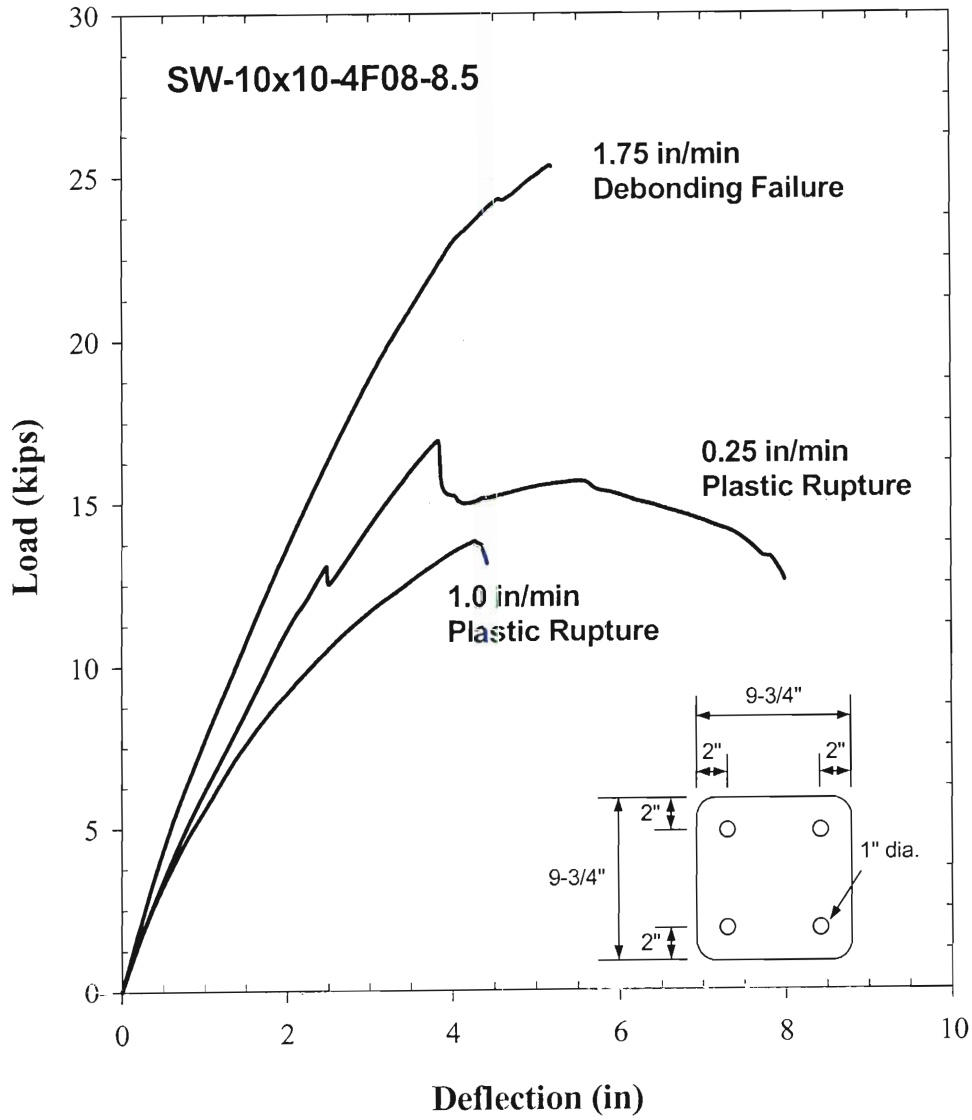


Figure A-16. Load-deflection curves of 10x10 SEATIMBER® components with various loading rates